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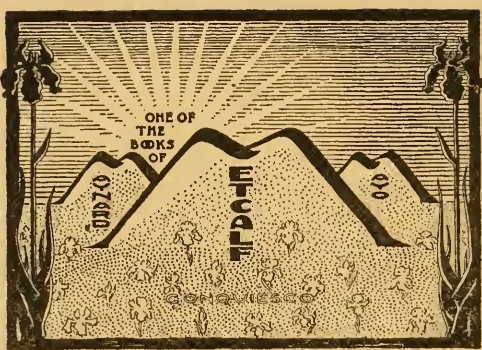

Maynard M. Metcalf

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THE

MICROGRAPHIC DICTIONARY;

A GUIDE TO THE EXAMINATION AND INVESTIGATION

OF THE

STRUCTURE AND NATURE

OF

MICROSCOPIC OBJECTS.

BY

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FOURTH EDITION.

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ILLUSTRATED BY FIFTY-THREE PLATES AND EIGHT HUNDRED AND EIGHTEEN WOODCUTS, CONTAINING FIGURES OF 2680 OBJECTS.

VOL. II.—PLATES.

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PREFACE.

ON arriving at the conclusion of their labours, the Authors feel that some apology is, in the first place, due to the Subscribers, for the extent to which the number of these pages has been increased beyond the original estimate. They have, however, the pleasure of stating that no complaints have been addressed to them on this head; but, on the contrary, strong injunctions, when the work was somewhat advanced, to allow no considerations of arbitrary limits to prevent equal justice being done to the subjects falling under the later letters of the alphabet. They feel therefore that due allowance has been made for the difficulty of calculating beforehand the extent of a work like the present, and that the circumstance which has chiefly led to the enlargement of the volume, namely the revision of the articles at the latest moment before committing them to press, has been duly taken into account.

Secondly, a few observations may be offered on the character, objects, and uses of the work. It was stated in the Prospectus, that the 'Micrographic Dictionary' was offered as an index to our knowledge of the structure and properties of bodies revealed by the Microscope. The Authors venture to hope that their work may possess many useful qualities beyond those strictly implied in the above definition.

Few or none of the works hitherto published have dwelt upon the manner in which observers might judge of the structure of objects from the appearances presented under the Microscope. There are works treating of the construction of the mechanical and optical parts of the instrument, and the manner of using them, of the methods of preparing objects for examination; and to these are usually appended lists of objects presenting interesting appearances. But there exists no work which will direct the Student how to vary the methods of preparation of the objects examined, so as to elicit their true structure.

An Introduction has been prefixed to the 'Dictionary,' affording instruction for the selection of a Microscope and the accessory apparatus, explaining the manner of using these, and particularly the precautions requisite with the less perfect but more economical foreign glasses; and, lastly, entering minutely into what may be called microscopical manipulation and the special education of the eye.

Many valuable contributions to our knowledge of the structure or functions of microscopic organisms are probably lost through the inability of microscopic observers to ascertain readily the name and position in Nature of objects which fall under their notice. It is hoped that the very

numerous illustrations to this work will form a valuable guide in such cases, and render the descriptions of microscopic animals and plants, of minute structures, tissues, &c., which form the main body of the volume, a real dictionary of objects. At the same time it is not unreasonable to expect that much advantage may be derived from the attention that has been paid to directing observers to subjects and disputed points on which new information is desirable.

To the lovers of Comparative Anatomy, Physiology, or of the Natural History of the microscopic members of the Animal and Vegetable Kingdoms, the Authors have endeavoured to furnish, without departing from the principal purpose of the work, something more than a mere descriptive catalogue of objects, and the means of examining them. Numerous articles on various subjects have been written with a view to enable readers, by the help of the system adopted, and references printed in SMALL CAPITALS, to acquire a general knowledge of particular departments of science. Thus, taking a departure from the article ANIMAL KINGDOM or VEGETABLE KINGDOM, the reader may proceed to the *Classes* and *Orders* there enumerated; under the latter will be found a general description of these (where the microscope is much required in their investigation), followed by a reference to the *Genera*, under which is given more or less extensive information on the *Species*, according to the state of knowledge, or as the subject has seemed to require. Proceeding from the article TISSUES, in like manner, the details may be gradually collected by tracing them through the subdivisions by means of the references. Many other general articles are given, with such headings as the names of well-known organs or substances, of vital or other phenomena, &c., under which could be conveniently collected references to a variety of miscellaneous information scattered through the alphabetical arrangement. Those who use the volume in this way will probably derive the greatest amount of advantage from it; they will, it is true, most clearly perceive the deficiencies inevitable in a great measure to a work having such an extensive field, and at the same time so limited a compass.

The results of a large amount of independent observation have been consigned to these pages; and, as the bibliographical references show, recourse has been had, as far as possible, to original sources for trustworthy and reliable information published at home and abroad. In connexion with this, some account may be given of the illustrations. In the Plates, a large number of the figures are original, drawn from the objects either by the authors or by Mr. Tuffen West; in many cases, however, figures of species have been designedly taken from original plates, especially when the verbal characters were doubtful. The Authors feel bound to express their thanks to Mr. West for the manner in which he has applied his well-known skill and accuracy to those engravings which were entrusted to him: many of them, indeed, appear at first sight somewhat crowded and on a small scale; but they will be found in most cases to display very clearly the parts of objects on which *systematic* or *structural characters* depend, the chief design of all the illustrations of this work. With regard

to the engravings in the text, a portion have been selected, after comparison with the objects themselves, from the excellent illustrations of the *Mikroskopische Anatomie* of Kölliker. Most of the woodcuts of plants are careful reproductions of drawings contained in original works and memoirs by Kützing, Corda, Tulasne, Bischoff, Bruch and Schimper, and others, prepared for Payer's *Botanique Cryptogamique*, to which, as to almost every illustration in this volume, the *magnifying power* used has been added. Had not these beautiful woodcuts been accessible to the publisher, it would have been impossible to have provided this work so richly with illustrations.

The authors have much pleasure in acknowledging their obligations to the Rev. M. J. Berkeley, Messrs. Westwood, W. S. Dallas, Sollitt, and Tuffen West, for the loan of authentic specimens, or for information kindly afforded on various subjects, and to Dr. William Francis, for constant advice and assistance during the printing of the work.

JOHN WILLIAM GRIFFITH.
ARTHUR HENFREY.

London, December 1855.

PREFACE TO THE SECOND EDITION.

I REGRET that the task of writing the Preface to this Second Edition of the 'Micrographic Dictionary' falls upon me alone, the hand of Death having just been laid upon my distinguished and most amiable friend and coadjutor. It will, however, be satisfactory to the reader to know that the whole had passed under the hands of the late lamented Professor Henfrey, and that he had taken his share in correcting for the press all but the last three sheets.

The work has been revised throughout, and has received considerable alterations and additions. The progress of Structural and Physiological Botany was always assiduously watched by Professor Henfrey; and the articles on Botanical subjects have been greatly enriched by the additions which his extensive and accurate knowledge suggested to him. Great improvements have also been introduced into many of the articles relating to the Animal Kingdom, especially in the classes Insecta, Tunicata, Polyzoa, and Foraminifera, some members of which have lately attracted much attention. The new figures added are also numerous.

The critical reader will, it is hoped, consider that the great range of subjects embraced, renders it impossible to do justice to all of them; and in

many cases we have been compelled to limit our notices to little more than the characters by which the objects are distinguishable in their respective classes, &c. This has always been a great point in the composition of the work—to enable the microscopic observer to discover what any object is which may be presented to him, and by the aid of the Bibliography to refer to more extended treatises for further details.

Our thanks are again due to those who have kindly lent us aid, especially to Mr. Dallas for the articles Aphidæ, Chalcididæ, and Cynipidæ; and also to those who supported us by their friendly notices of our former labours.

J. W. G.

December 6, 1859.

PREFACE TO THE THIRD EDITION.

At last the third Edition of the 'Micrographic Dictionary' is completed. But I feel that some explanation, or even apology, to the Subscribers is requisite, considering the delay that has occurred in its issue. To ill-health and press of professional engagements this is attributable. For some time, being constantly in the hope of rapidly completing the work, I hesitated to place it in other hands, until at last I found it essential to do so. The editing of the work subsequently to the letter H was therefore transferred to Prof. Duncan, whose name will form a sufficient guarantee that it has been satisfactorily accomplished.

In regard to the alterations made in this Third Edition, it will be noted that nearly 100 pages of new matter have been added. The original articles have been revised according to modern researches and views, so as to represent, as far as space would permit, the present state of knowledge.

When I state that the Articles upon the Fungi were intrusted to the Rev. M. J. Berkeley, and those upon the Foraminifera to Prof. Rupert Jones, the reader will surely feel confident that they have been carefully and faithfully elaborated. For some valuable notes on the Lichens I have to thank the Rev. W. A. Leighton.

An important novelty in this Edition consists in the accentuation of the names forming the headings of the articles. The classical pen of the Rev. M. J. Berkeley has afforded aid upon this point also.

The Plates have all been newly engraved upon copper, thus rendering the figures of the objects more sharply defined. Three new plates have been added, and several of the original Plates have been re-arranged and improved.

J. W. G.

December 2, 1874.

ERRATA.

Page 51, col. 1, line 5 from bottom, *for* Pl. 23 *read* Pl. 30.
56, col. 1, line 14 from bottom, *for* Plans *read* Plants.
60, col. 2, line 11 from bottom, *for* Pl. 2 *read* Pl. 6.
68, col. 2, line 21 from top, *for* labrum *read* labium.
87, col. 1, line 15 from bottom, *for* Cyclostomata *read* Ctenostomata.
91, col. 1, line 26 from bottom, for *rhitidome* read *rhytidome.*
103, col. 2, line 6 from bottom, *for* muscular *read* molecular.
112, col. 1, line 25 from top, *for* inorganic *read* organic.
168, col. 2, line 25 from bottom, *for* structurs *read* structures.
221, col. 2, line 11 from top, for *spirillium* and *spirillia* read *spirillum* and *spirilla.*
231, col. 2, line 9 from bottom, for *Cestoiden* read *Cestoïdes.*
261, col. 2, line 10 from top, for DIDIMIUM *read* DIDINIUM.
318, col. 1, line 27 from top, *for* introcellular *read* intracellular.
495, col. 1, line 29 from top, *for* $\frac{1}{2500}$ *read* $\frac{1}{25000}$.
525, col. 1, line 8 from bottom, *for* always *read* also.
577, col. 2, line 16 from bottom, *for* PARAPHY'SES *read* PARAPH'YSES.
621, col. 1, line 12 from bottom, *for* Actinaria *read* Actinozoa.
661, col. 2, line 20 from top, *for* pearlite *read* perlite.
664, col. 1, lines 22, 25, and 26 from bottom, *for* Noseau *read* Nosean.
675, col. 1, line 5 from bottom, for *Symbistes* read *Symbiotes.*
682, col. 1, line 12 from top, for *Spirillum* read *Vibrio* ; and *for* inflexible *read* flexible.

PREFACE TO THE FOURTH EDITION.

In regard to the completion of the Fourth Edition of the 'Micrographic Dictionary,' few remarks seem necessary. It may be stated, that the work has been thoroughly revised. The systematic portions of the Animal and Vegetable Kingdoms have been re-arranged according to modern views, as far as is consistent with reference to existing standard treatises and monographs of the individual subjects. The structural portions have also been enlarged and corrected in relation to recent observations and experiments. The very large number of new genera, founded especially by Kent, Brady, and Buckton, have been noticed, but in many cases somewhat briefly, especially when the objects are rare or not likely to be easily accessible. Had this not been done, the work would have been extended beyond the proposed limits; the references to the original descriptions have, however, always been appended. Five new plates and some new woodcuts have been added; and the former plates have been altered and corrected where found necessary. The older nomenclature of the chemical substances is retained, according to which these are usually known and purchased. We have to thank Mr. Rutley for his excellent plate and article on Rocks; and Mr. Harkness, of the Government Excise department, for his plate of Adulterations. The articles on the Fungi and the Foraminifera have again been revised by the Rev. M. J. Berkeley and Professor Rupert Jones. Our thanks must also be given to Mr. McLachlan and the Rev. Mr. Leighton for some friendly and valuable remarks. Nor must we fail to acknowledge the assistance afforded by our publisher, in the loan of some of his expensive works; and the aid derived from the use of the magnificent Library of the Royal College of Surgeons, with the courtesy of the Librarian, Mr. Chatto. We hope and trust that this Edition will be found as usefnl and interesting as the three previous ones have surely been.

J. W. G.

December 26th, 1882.

INTRODUCTION.

I.—USE OF THE MICROSCOPE AND EXAMINATION OF MICROSCOPIC OBJECTS.

Before entering upon the special consideration of the Microscope, of which the Introduction treats, it may be well to make a few remarks upon the general use of the instrument in the examination of minute objects.

The Microscope will either be used as a means of affording amusement, or with a view to scientific research. In the former light, no philosophical instrument can compete with it, in regard to the great variety, the beauty, and the wonderful phenomena of structure which the minute objects it enables us to examine display, even independently of the consideration of the functions and uses of their several parts. In this light also, the investigation of the comparative structures and properties of various bodies or substances used in daily life as articles of food, dress, &c. will form subjects of intense interest to any one who may be possessed of the instrument. The mysterious phenomena of growth, reproduction, and crystallization may also be watched throughout their progress, just as we can see the effects of parts of machinery with the naked eye. But while the sense of sight is thus gratified, the mind will not be unoccupied; for every fresh appearance will impress a new fact: so that here we have both amusement and instruction combined.

It is, however, to the use of the Microscope as a means of scientific research that our remarks are most necessary; for in this great care and consideration are required, and these are very apt to be neglected by those who are unaccustomed to employ this valuable instrument.

The Microscope as a means of investigation might perhaps be thus defined: the microscope is an optical instrument constructed in order to enable us to investigate the characters and properties of those objects which we are unable to study with the unassisted eye, on account of their minute size.

The use of the Microscope will resolve itself into either that of proving the structure of a known object, or determining that of a new one; and in thus applying it, exactly the same precautions must be adopted, and just the same course pursued, as if the object under

examination were distinctly visible to the unaided eye. The above formal definition of the true use of this valuable instrument is requisite, because it is very frequently used simply as a means of *viewing* minute objects, and judging of their nature from the mere inspection of them under the conditions in which they naturally or accidentally occur. Such a procedure, the most casual observer must be well aware, is never trusted alone in the examination of objects visible to the naked eye, being almost sure to lead to erroneous conclusions. Consider the common course pursued in the macroscopical examination, or that with the unaided sight, of a body for the first time presented to our notice! The first point is the examination of its general appearance and colour; the relative position of the eye of the observer and the object is then changed, so that an idea of its solidity may be obtained; its weight is next perhaps determined by taking it in the hand; it is presented to the light in various ways, in order to judge of its transparency, and of the optical properties of its surface. If the object be at a distance, its size is judged of by comparing its apparent size with that of adjacent bodies, whose dimensions are approximately known; and its luminousness is also taken into consideration, it being known generally that the nearer bodies of the same size are to us, the more luminous they appear. The observer then is either satisfied with the conclusions drawn from reasoning upon the results thus obtained, or he makes besides a chemical examination.

Again, care should be taken to avoid forming an opinion upon the normal or abnormal state of an organic structure, without a previous knowledge of the natural structure of organic tissues. We therefore recommend the student, before he thinks of recording his observations, to begin by testing the structure of any objects which may come in his way, or that of the Test-objects which we have described, according to the rules laid down in the second part of this Introduction.

It may be remarked for those who have but small means at their command, and who are unable to procure a first-rate English microscope, that perhaps very many of the facts elicited by the use of this instrument have been determined by our continental neighbours with far less perfect instruments, who have made up for the imperfections of their instruments by extreme patience, care, and repeated observation; which can be done to an extent that would scarcely have been anticipated.

We have alluded to these sources of error merely for the purpose of warning future observers, and impressing upon them the importance of making themselves acquainted with the difficulties attendant upon microscopic investigations, and with the best means of overcoming them. In fact, it may be briefly stated that the object of the present work is to guide the microscopist in his researches, to give him a notion of the manner of making these researches, also some account of the characters, microscopic structure, and properties of objects in general, and to show how he may most easily arrive at satisfactory results.

But there are difficulties inherently connected with the examination of microscopic objects, which are not encountered when objects are examined with the naked eye. One of these is that, with the ordinary microscope objects are only viewed with one eye; hence we lose the direct power of distinguishing solidity, &c., and are compelled to resort to indirect means for these purposes. This difficulty is to some extent overcome by the construction of binocular microscopes. Again, the ordinary objects around us are also usually viewed by reflected light, whilst with the microscope they are mostly viewed by transmitted light, and we are consequently much less practised in judging from the appearances of objects thus illuminated, and are therefore liable to err.

Another, but a less important difficulty in microscopic investigations, or at least manipulations, consists in the image of the objects being inverted. Erecting eyepieces, as they are called, will obviate this difficulty; but as they are expensive, and interfere with the distinctness of the images of the objects, and as the difficulty is to a great extent got over by practice, they are rarely used.

Another very serious source of error lies in the tendency to reason from analogy as to the structure or nature of a body viewed under the microscope. Any one who pursues this course has his mind prejudiced by preconceived notions, and becomes in fact no observer at all.

It need, moreover, be merely remarked that the ordinary appearance of objects to the naked eye depends in all cases upon a molecular structure, which is generally microscopic, the ordinary appearance being the optical result or expression of this structure; and since totally dissimilar microscopic structures may present similar appearances to the unaided eye, judgment as to the nature of the former founded upon the latter can be of but little value. The reader will remember that the common capability of distinguishing objects or structures by their appearance has been derived, so to speak, from practice and experience of effects; and when we bear in mind that the experience and practice in the study of the causes are attainable, the superiority of the latter must be evident.

Next to the improvement effected in the optical construction of the microscope during the last few years, must be placed that of the method of investigation. Formerly almost all microscopic bodies possessing different forms and appearances were considered distinct beings, and were named accordingly. By the present method, prolonged observation is adopted to follow the changes which the individual bodies undergo; whence it has resulted that numbers of them have been found to be simply different stages of each other. Thus a large amount of useless nomenclature and confusion is being removed from the domain of the microscopic world.

Above all, however, it must never be forgotten that microscopic investigations require more time and patience than perhaps any others, even in regard to the determination of simple points of structure and qualitative composition. In fact, notwithstanding the innumerable observations made upon the more minute objects, such as the scales of insects, the markings on the valves of the Diatomaceæ, the fibrillæ of muscular fibre, &c., such differences of opinion are still entertained, that it can by no means be asserted that the structure of these bodies is positively known.

The time has passed at which the value of microscopic research could be called in question. The wonderful insight gained by its use into the structure and functions of the various organic beings belonging to the Animal and Vegetable Kingdoms, the aid it has afforded Geology, the so-called practical applications it has permitted in improving the arts, in detecting adulterations, and in defeating crime, moreover the almost positive certainty we have obtained that it is capable of displaying all the real structure which bodies possess, save that of their ultimate molecularity, which will probably always be hidden from us, are sufficient to deprive this question of any interest.

Lastly, if it were required to prove design in the creation, this could not be more easily effected than by the examination of the structure of microscopic organisms.

We have expressed our intention of not entering upon a description of the microscope as an optical instrument, because it would have been requisite to tread widely the field of general optics, which our space does not permit. We would therefore advise those who

wish to become acquainted with the microscope as an optical instrument, first to study the general laws of optics, which may be done through the medium of any of the works or treatises on Natural Philosophy—as the article 'Optics' by Herschel in the Encycl. Metropolitana, Brewster's 'Optics,' Lloyd's 'Manual,' Deschanel's 'Optique,' Verdet's 'Leçons d'Optique Physique,' Nägeli and Schwendener's 'Mikroskop,' 'Ganot's 'Physique' (transl. by Atkinson), or Rodwell's 'Dictionary of Science.' Perhaps the second work is the best for the general reader; it is an old standard work, but greatly behindhand in regard to the use of the microscope. They may then proceed to the application of these laws to the various optical parts of the microscope. This will be found in the works enumerated at the end of the Introduction.

We must not, however, omit a notice of the principles which should guide in the selection of a microscope and the accessory apparatus, because a large number of microscopes are at the present day sold, frequently at no mean cost, which, although well calculated to afford amusement, are utterly valueless for the purpose of scientific investigation. To those to whom money is no consideration, we may recommend with safety, as the best which can possibly be procured, such as are manufactured by Ross, Smith and Beck, or Powell, of London. These makers have a thorough knowledge of the instrument, and a reputation at stake; hence there is little occasion to test their instruments. But it may happen that a person may not wish to expend so much money as the purchase of these instruments requires, may wish to procure a foreign instrument (and these are cheaper), or may meet with one second-hand. A word or two may then be of service in guiding them in their choice; for a microscope may look very well and very handsome, yet be worth but little. It must, however, be borne in mind that there is much room for opinion in these matters; for according to what any one has been accustomed to, or according to prejudice arising from what he may have heard a supposed authority say, so will an instrument or a piece of apparatus be regarded as requisite or of importance, or not. Our statements rest upon our own experience in the long-continued use of the instrument, and as such they must be taken.

First, it may be remarked that the microscope is usually regarded as composed of the stand, body, stage, eye-pieces, and object-glasses: and the object-glasses are generally sold separately; for by means of an "adapter" they can be applied to any microscope.

In regard then to the stand, body, &c.: the *stand* should be firm, and so heavy and its feet so arranged, that the instrument cannot be easily overturned.

The *body*, whether the microscope has one body only, or is binocular, should be about 8 or 10 inches in length; in many of the foreign and cheap English instruments the body is short, and the eyepieces are adapted accordingly; but this adaptation is decidedly objectionable.

Whether the microscope shall be binocular or not must be a matter of opinion. In the binocular microscopes there are two bodies and two eye-pieces, the rays of light just above the object-glass being divided by a refracting prism into two portions, one of which passes through each tube; in this way the stereoscopic view of objects is obtained. The binocular arrangement is an additional expense; it can be added to any microscope; but any binocular microscope can be used as a single-bodied instrument (See BINOCULAR).

The microscope should be so constructed that the body can be inclined at any angle desired, so that the observer may examine objects while sitting. Many persons, however, prefer to use the microscope with the body placed perpendicularly; and when chemical

reagents are to be applied this position is essential; but when long-continued examination of an object is required, it becomes very painful and fatiguing to keep the head in the position which the perpendicular position of the body requires. Moreover, as in a microscope with the joint or arrangement by which the body can be inclined the body can always be placed perpendicularly, the joint is decidedly advantageous. Again, it is almost essential when the camera lucida is used. A brass pin or some similar contrivance should be placed near the joint so as to check the motion of the body of the microscope when it reaches the horizontal position; no microscope should be without this.

In most microscopes a tube sliding within the body and carrying the eyepiece forms a "draw-tube." By drawing this out the magnifying power becomes enlarged without changing the eyepiece; it is very useful with the erector or erecting-glass (p. xxii); and serves occasionally to produce slight corrections for variations in the thickness of the covers, with immersion-lenses.

The microscope should have a coarse *rack-and-pinion* movement or *quick motion* for adjusting the focus of the lower powers or object-glasses; and when used with an object-glass of about half an inch focus, the image of the object examined whilst coming in and going out of focus, must not appear to move from one side to the other of the field when the body is raised or depressed by the coarse movement. Also when the milled head of the coarse movement is rotated, the motion should feel smooth, not irregular, uneven, or jerking. In some foreign microscopes, the effect of the coarse rack-and-pinion movement is replaced by the sliding of one tube within the other, the body consisting of two tubes working after the manner of those of a telescope. This arrangement is very objectionable, although used by some very good observers, who probably have more tact than most people, and who do not use such high powers as they ought; for when the highest powers are used it is perfectly intolerable. The objection is somewhat overcome in some microscopes by the existence of a fine movement; but we regard the rack-and-pinion coarse adjustment as essential.

A *fine movement* or *slow motion* is indispensable; for with the higher powers (one eighth and upwards) it is impossible to adjust the focus without it. When the finger or fingers are applied to this in its use, no apparent motion of the object must take place; should this occur, the movement is worthless, unless, at all events, it is very slight, and this when tested with the high powers.

When the milled head of the fine movement is turned backward and forward, as in use, the motion should be perfectly even, and should be produced very easily, with slight pressure only of the finger or fingers; moreover no difference should be distinguishable between the two directions in which it is turned, but it should move with equal ease in both.

The *field* or luminous disk on which the objects viewed through the microscope are apparently delineated, should have its marginal line clear and black. If this line appear coloured, the eyepiece is not as it should be.

The *stage* should not be too small, (say less than 3 inches in diameter). To the best instruments a moveable stage is adapted; but whether this is essential or not is considered a matter of opinion. Undoubtedly with low powers the moveable stage may be dispensed with, and is not often used; but with the higher powers its absence is felt greatly, and we should say that it is essentially necessary. In most of the English microscopes, whether provided with a moveable stage or not, there is a "sliding piece" for producing the back-

ward and forward motion of an object, the lateral motion being effected by direct application of the fingers. If the body of the microscope is to be used in the inclined position the sliding piece or a moveable stage becomes essential.

If the moveable stage be present, the "milled heads" should be pretty large, so as to be readily grasped, and a flat object should remain in focus whilst traversing the field by the movement of the stage. The stage should also be very thin.

The *mirror* should have one plane or flat face, and another concave. It should not be too small; and its centre should coincide with the axis of the body of the microscope. A double arm enables the mirror to be brought more considerably to either side, so as to throw more oblique light upon an object.

So long as the above conditions are fulfilled, the general form and arrangement of the stand and its parts are of little consequence. It must also be remembered that the complication and accuracy of the apparatus required will vary according to the kind of investigations pursued. Thus the structure of the various tissues of animals, and that of most plants, can be satisfactorily studied with apparatus which is totally insufficient to display the structure of certain of the more minute and difficult objects; but, on the other hand, it follows that if a peculiar structure can be shown to exist in any kind of objects by a complicated apparatus, which cannot be demonstrated by a more simple or less perfect apparatus, the study of the structure of any object not previously examined must always be attended with uncertainty so long as it has not been tested by the more perfect kind of apparatus,—provided the microscopist has not acquired the art of replacing the imperfection of his apparatus by superior tact and management, which can be done to a great extent.

Object-glasses, often called *Objectives*.—These form the most important portions of the microscope. The value of the object-glasses depends mainly upon their freedom from chromatic and spherical aberration, and upon the magnitude of their angular aperture. The freedom from the former renders them good in defining power, *i.e.* in exhibiting clearly the margins or outlines of objects or structures; whilst large angular aperture renders them capable of penetration, or of resolving the more delicate markings upon the surface of objects. But there are two kinds of penetrating power, as we shall show in the article "TEST-OBJECTS," where we have entered more fully upon this subject.

As in the case of the stand &c. of microscopes, so in regard to the object-glasses; the best are made in this country, and can be obtained of first-rate quality of the three makers above-mentioned. But the French and German object-glasses have been very greatly improved in late years, and are now largely used, especially the immersion-glasses as they are called (OBJECT-GLASSES); and some of these resolve perfectly most of the difficult valves of the Diatomaceæ; and they are cheaper than the English glasses. The names of Hartnack, Zeiss, and Gundlach are well known as those of excellent makers. Some of the American object-glasses also, which are but little known in this country, must stand in the first rank in regard to excellence in defining and especially penetrating power. When a glass of unknown value, however, presents itself, it should be tried upon the test-objects.

The defining power may be tested by the examination of the objects figured in Plate 1. figs. 1 to 4.

The outlines or margins of these objects must appear black, well defined, and perfectly free from colour, not misty, nor red or green; they should retain this appearance when the higher eyepieces are used, of course some allowance being made in regard to the sharpness of outline, which will appear slightly broader and less defined, but nowise interfering

with the distinctness of the image of the object. The various parts of an object lying in the same plane, as a transverse section of whalebone, should also be visible at the same focus; the lines upon a micrometer used as a slide will also serve to test this point. It is not, however, of very great importance, especially with high powers; but it is a character of a superior object-glass.

If the definition of the glass be good, the field flat, and the power adequately high, it will also exhibit the structure of the objects in Plate I. figs. 5, 6, 10, 12, and 13 clearly and distinctly; it is then of sufficiently good quality for nearly all the purposes required in the investigation of animal and vegetable structures.

The exhibition of the objects illustrated by Plate I. figs. 6, 7, 8, 9, 10, 11, 12, and 13 requires the first kind of penetrating power, but it does not require large angular aperture. The second kind of penetration, however, requires, above all, large angular aperture, independently of any other superiority; *i. e.* a glass may be perfectly corrected as to defining power, and exhibit the above objects well, yet when the valve of a *Pleurosigma* is subjected to it the markings cannot be distinguished without particular appliances, which produce the same effect as an increase of angular aperture in the object-glass. As this property is therefore principally dependent upon the angular aperture, this should be determined by direct measurement; the method of doing which is described under the article "Angular Aperture," in which also is contained a list of the various apertures of the best glasses, so that the approximation in the case of any glass to these magnitudes will afford an indication of its quality. It must be observed that increase of angular aperture in an object-glass involves an increase in price.

The following remarks may perhaps assist in guiding the judgment in regard to the selection of an object-glass:—

Large angular aperture is of less importance in the case of a low than of a high power.

Large angular aperture is neither requisite nor advantageous in physiological and medical investigations in general.

Whether a glass of larger aperture will exhibit any further structure than one of less aperture has already done, can nearly always be predicted from other means.

Object-glasses of high power and large angular aperture require to be brought very close to the objects viewed, which is a great disadvantage, rendering them useless for general investigations.

In regard to objects requiring large angular aperture for exhibiting their structure, much depends upon the management of the light; so that a glass may fail in exhibiting certain parts of structure in the hands of one of but little experience, whilst in the hands of another it may show them distinctly. Hence the direct measurement of the angle is best, to determine what a glass is capable of exhibiting when properly used.

The student may perhaps find himself perplexed by the conflicting statements made by different renowned observers in respect to object-glasses. The illustrious Schleiden said that only a magnifying power of about 500 diameters is useful for scientific purposes, that with our present microscopes we may see whatever we like with a power of 3000, and that only the amplification of an object to the extent of 280 or 300 diameters is produced by the object-glass, all beyond this being effected by the eyepieces with an almost total loss of light. These statements were perhaps formerly true; but they do not apply to the modern object-glasses. The highest modern object-glasses will show minute objects with a power of from 600 to 2500 diameters with the lowest eyepiece, as clearly and well defined as the

ordinary glasses of 1-inch focus will show larger objects; hence enormous improvements have latterly been made in object-glasses,—the increased magnifying power being produced by the object-glasses and not by the eyepieces, by which means the visible images are rendered most distinct and trustworthy; for the object-glass alone produces the structural image of the object, which is magnified by the eyepiece, but the latter elicits no further structures.

According to modern views, about 800 diameters is the magnifying power of the object-glass which will resolve all visible structure. High eyepieces, even to 50,000 diameters, will magnify the images, but will not elicit further structures.

For ordinary useful purposes, the $\frac{1}{2}$ or $\frac{2}{3}$ inch and the $\frac{1}{4}$ inch object-glasses, with the first and third eyepieces, will suffice. With the draw-tube and the third eyepiece, the $\frac{1}{4}$ will magnify 900 diameters, which is sufficient for most ordinary investigations.

Recent investigators with very high powers, especially with immersion-lenses, have brought to light new structures hitherto overlooked; we need merely mention the muscle-rods (Plate 22. fig. 36 *c*), the spermatozoal membrane (Plate 50. fig. 25), and the cilium of *Bacterium* (Plate 1. figs. 19, 20), &c; but all the lenses made by the best makers, both English and foreign, are provided with an immersion-front. These structures, which are very difficult to exhibit with the older microscopes and object-glasses, show the importance of using very high powers, especially the $\frac{1}{16}$ or $\frac{1}{25}$ inch.

Diaphragm.—Most microscopes are provided with a diaphragm. It consists of a circular blackened revolving plate, placed beneath the stage and having a series of circular apertures of different sizes, each of which can be brought successively opposite to the axis of the body of the microscope. It serves to regulate the quantity of light in examining transparent objects; it also reduces the angle of the cone of the reflected rays. It is seldom, however, used, nearly the same effect being produced by the two different surfaces of the mirror.

Revolving Stage-plate.—One of the plates of which the moveable stage is composed is so constructed as to revolve in the same plane upon its axis, whereby an object may also be made to revolve in the same manner. This apparatus, however, has some disadvantages in the older microscopes; for it renders the stage heavy and increases its depth; and the desired effect may easily be produced by rotating the slide with the fingers; moreover it is exceedingly difficult to place the object in the centre of rotation. It is however, provided in the best modern instruments, and is by many considered of importance; the old thickness of stage has also been avoided.

Spring Clamping-piece is intended to fix the slide upon the stage. It is of little use provided the slides are of the proper length, which we have given; if they are longer, the clamp will prevent the accidental displacement of an object in changing the power, &c. It serves, however, to fix the slide in viewing objects by oblique light, when the slide projects beyond the edge of the stage, and to prevent its tilting over.

Forceps are essential for holding opaque objects, such as insects, and viewing them in different positions; to allow of which, the handle of the forceps is made capable of revolving.

The *Disk-revolver* (Beck) is a very useful apparatus. It serves to bring into view all parts of an opaque object, but that which is attached to the disk.

Dark Wells are metallic cups of various sizes, blackened inside, and serving to prevent the reflection of light upon opake objects from below. They are supported in a holder,

moveable in an arm which is inserted into some part of the stand of the microscope. Their purpose is equally well effected by a slide beneath which a piece of black velvet has been fastened by marine glue.

Achromatic Condenser.—This consists of an achromatic object-glass, or set of lenses, placed in an inverted position beneath the stage, usually in a "secondary" stage, and moveable in all directions in its own plane and in the direction of its axis. It serves to condense the light reflected by the mirror to a focus upon the object, and to exclude all extraneous light. It is essential in examining minute objects with high powers; in fact, the structure of many objects cannot be made out without it. In the excellent Gillett's condenser, a rotating diaphragm is placed behind the back glass of the combination forming the condensing object-glass, perforated with a series of apertures of various sizes, some of them being circular, whilst others are annular—the former diminishing or increasing the cone or pencil of rays reflected from the mirror by excluding the lateral rays, the latter admitting only the lateral rays, the central ones being intercepted by the portion of the diaphragm within the ring, so that the angular inclination of the transmitted rays may be increased or diminished at will. In its most improved form it consists of two concentric revolving diaphragms, with central stops, by which the relative sizes of the apertures and stops can be varied; and its angle of aperture is 170° (Powell). In the latest form, it represents a "swinging" substage. The markings upon many of the Diatomaceæ can only be made out when examined by oblique light, as procured by intercepting the central rays, which effect is produced by this modified achromatic condenser. The same effect may be produced to some extent in one of the achromatic condensers of the old form, provided the compound lenses of which the object-glass in the condenser consists are separable, by pasting or temporarily placing a circular disk or "stop" of black paper exactly upon the centre of the plane face of the innermost combination. The diameter of the disk should amount to about two thirds of that of the surface of the combination to which it is applied. The combinations are then fitted together as they were at first. This stop intercepts the central rays, thus diminishing the amount of light transmitted; but this difficulty is easily got over. When the achromatic condenser is used, the flat surface of the mirror should form the reflecting surface, and care skould also be taken that the axis of the condenser coincides with that of the object-glass. To ensure this, a small cap of brass having a minute circular aperture in its centre should be fitted to the lower part of the tube in which the condensing lenses are situated. When the object-glass is properly adjusted with regard to the condensing lenses, the field of the microscope will appear black, excepting at a minute luminous spot. This spot must be made to occupy the centre of the field by moving the laterally adjusting screws of the condenser, or the body of the microscope; as soon as this has been effected, the brass cap must be removed. Or Ross's centering-glass may be used: this consists of a tubular eyepiece cap, in which are two plano-convex lenses so adjusted that the image of the aperture in the object-glass, and the images of the apertures of the lenses and diaphragms of the condenser, may all be seen in focus at the same time, and their centricity or excentricity determined.

The focus of the condenser must be made to fall upon the object, which can be effected by raising or depressing the condenser until the window-bars by day, or the lamp-flame by night, are brought into focus; but if the image of these interferes with the view of an object, the condenser must be lowered to displace them.

The paper-stop may be very advantageously replaced by a blackened metallic stop placed

behind the first pair of lenses of the condenser, and screwed into the top of the condenser in the place of the ordinary diaphragm. Neither of these kinds of stop equals in convenience the improved Gillett's condenser, because with the latter the number of rays transmitted or intercepted, and the degree of their obliquity, can be varied by the simple rotation of the diaphragms. The *spot-lens* is also used for the same purpose. This consists of a very convex plano-convex lens, placed beneath the stage, the central rays being intercepted by a stop.

The central stop is generally used when objects are examined with the higher powers. The power used in the condenser will vary greatly according to the kind of object under examination. If a considerable amount of light be required without obliquity of the rays, the condensing power should be lower than that of the object-glass. If great obliquity of the rays be required, the higher the power of the condensing lenses, and the larger their angular aperture, the better. When the achromatic condenser is suitably arranged in regard to centering, and the condensing object-glass or set of lenses is properly selected and adjusted, the structure of minute objects is displayed in a manner with which those who regard the condenser as useless must be utterly unacquainted. Many very delicate objects are rendered most distinct by using the smallest aperture in the diaphragm of the condenser, so that the admitted rays are almost parallel. But this requires a very powerful light.

Extra Eyepieces.—Always one, and mostly two or more eyepieces, or oculars as they are sometimes called, are obtained with the microscope when purchased: but the highest eyepiece which is made should always be procured; for although high eyepieces are so far objectionable that they magnify the imperfections of the image formed by the object-glass as well as the image itself, yet they frequently render parts of structure distinct which are perhaps only just perceptible with a lower eyepiece. Kellner's orthoscopic eyepiece, in which the lower lens is doubly convex, gives a very large and flat field.

Polarizing Apparatus or Polariscope.—This usually consists either of two plates of tourmaline, or of two Nicol's prisms. The latter are generally used, and are preferable on account of their freedom from colour. They are composed each of two half-rhombs of calcareous spar cemented together so as transmit only one image. The prisms should appear perfectly clear and colourless, and free from scratches and veins; and when, on holding them to a light, the uppermost is rotated so as to occupy a particular position with regard to the other, no light should be transmitted through them.

The polarizing apparatus is useful in bringing to light certain peculiarities of structure which cannot be detected in any other way; and is particularly useful in the study of minerals (ROCKS). A substitute may be made of two crystals of the iodo-disulphate of quinine, dried upon and cemented to circles of thin glass. In use, one is placed beneath the object, and the other on the top of the eyepiece.

Spectroscope.—The spectroscope, as applied to the microscope, is a somewhat expensive apparatus, and requires great practice in its application. It is, however, most important in many investigations. See SPECTROSCOPE.

Side Condenser.—This consists of a large doubly convex or plano-convex lens, or "bull's-eye," of short focus, 2 or 3 inches, mounted upon a brass arm, which slides up and down a rod placed perpendicularly in a stand. The arm should be capable of being lengthened, and the stand should be so broad and heavy that there need be no fear of its being overturned.

Its use is to condense the light upon opaque objects. When used, it is placed between the object lying upon the slide under the microscope and the lamp or other source of light, which should be about 6 or 7 inches from the object, the plane surface of the lens being at right angles to the direction of the rays of light, and next the object; and the lens must be brought so close to the object that the focus falls upon the latter. Sometimes a "small condensing lens" is used to concentrate the light already transmitted through the large condenser: this is usually fixed to some part of the microscope. A doubly convex lens of much longer focus than the bull's-eye lens, about 7 or 8 inches, will be found very useful for condensing the light upon the mirror when the achromatic condenser, stops, &c. are used with the highest powers. The arm of the bull's-eye lens may be adapted to hold either or both of the lenses.

Amici's prism is sometimes useful for throwing very oblique light through a transparent object. It consists of a flattened-triangular glass prism, the two narrower sides of which are convex. The third and broadest side forms the reflecting surface. The prism may be attached to a separate stand, or to the secondary stage. It is sometimes mounted on a pillar placed beneath a large brass slide, perforated in the centre. A triangular prism mounted in either of these ways forms a Reade's prism, and is used in the same manner. Amici's prism exerts a condensing as well as reflecting action.

Lieberkühn.—Some opaque objects may be well illuminated by a lieberkühn or silver cup; by which the light, first reflected by the mirror upon the concave surface of the cup, is afterwards reflected upon the object. It is not adapted for higher powers than the $\frac{1}{4}$ inch.

Wenham's Parabolic Reflector.—The discovery of the importance of excluding the central rays of light, and using a central stop for this purpose, is due to F. H. Wenham, who invented an apparatus in which this principle is taken advantage of. It consists of a brass tube fitted beneath the stage in the place of the ordinary achromatic condenser, terminated above by a hollow truncated cone the perpendicular section of which forms a parabola, with an internal polished silver reflecting surface. At the base of the parabola is placed a disk of thin glass, in the centre of which is cemented a dark well. In use, the central rays are stopped by the dark well, whilst the lateral rays, passing up the tube, impinge upon the parabolic surface, from which they are reflected upon the lower surface of the object. This apparatus, as modified by Shadbolt, is constructed of a solid cylinder of glass terminating above in a cone the surface of which has the form of a parabola and replaces the silver reflecting surface—and is the form now generally used. In objects viewed under this or any other form of black-ground illumination, the light reaching the eye is all reflected from certain suitably inclined surfaces of the object. This may be proved by placing a polarizer beneath the reflector, selecting as the object some small strongly polarizing crystals. On applying the analyzer, no colour will be seen, showing that the light has not passed through the object. Hence care must be taken in drawing conclusions from the appearances.

Brooke's Reflecting Apparatus.—The purpose of this is to illuminate objects by reflected light, so that they can be examined with the highest power. It consists of two parts; the first is essentially the same as the apparatus proposed by Wenham. The second consists of a small, flat, circular metallic mirror (a flat lieberkühn), perforated to admit the lower end of the object-glass, upon which it slides, and so arranged that the reflecting surface is in the same plane as the lower surface of the object-glass. When in use, the light is

reflected by the parabolic surface upon the plane reflector, and thence upon the upper surface of the object. This apparatus has lately given place to the next-mentioned.

Beck's Opaque Illuminator, which is a valuable piece of apparatus, is constructed thus:—A short screw-tube, or adapter, with an aperture in one side, is fitted between the end of the body and the top of the object-glass. Within the tube is a circle of thin glass, set obliquely, so that the light entering the side aperture is reflected by the circle upon the surface of the object, and passes upwards to the eyepiece. This may be used with the $\frac{1}{10}$ to $\frac{1}{50}$-inch immersion-lenses; and with it the hexagonal markings of *Pleurosigma angulatum* are distinctly seen, and the lines of fracture running through the areolæ (Moorehouse).

Tolles's Illuminator consists of a prism inserted in the side of the object-glass, between the front and middle combinations, so reflecting the light entering by a side aperture upon the object. See also Illumination.

A number of points in regard to the colour of objects, distinction of pigment-granules from minute air-bubbles, &c. may be decided by these pieces of apparatus. In questions of elevations or depressions of surface, conclusions must be based upon the analysis of the formation and arrangement of the shadows, and not upon the general appearance, because it is well known that objects, or parts of them, usually appear larger and more prominent in proportion to the amount of light reflected by them to the eye. Hence, for instance, little depressions, which are in fact extensions of surface, by reflecting more light than the surrounding flat or nearly flat surfaces, would appear very brilliant and luminous, and thus resemble elevations.

Camera Lucida, and steel disk or *Mirror* of Sömmering.—One of these is requisite for drawing from the microscope. The camera lucida resembles that commonly used in sketching landscapes &c., but is provided with a fitting adapting it to the eyepiece. The mirror of Sömmering is a plane mirror of polished steel, less in diameter than the pupil of the eye, supported opposite the focus of the eyepiece by a small steel arm attached to a split ring which grasps the eyepiece by a spring-action. There is one disadvantage attending the eyepiece of Sömmering, viz. that it inverts the image of objects, which the camera does not. When either of these is used, the body of the microscope must be placed horizontally, and the axis of vision be directed perpendicularly; the image of the object will then be seen upon the table, and may be traced with a pencil. In using the camera, it must be remembered that the size of the object will appear greater as the distance between the eyepiece and the table is increased; hence it is best always to place the microscope in one and the same position when about to use it for drawing, so that the extent to which the objects are magnified by the same power may always be the same. The pin mentioned at page xv is invaluable for this purpose. By placing a micrometer-slide upon the stage, and comparing the magnified image of the divisions with those on a known measure, such as a graduated rule, the magnifying power can always be checked, and any error arising from varied distance determined.

Beale's neutral-tint glass reflector is often used as a camera, and is inexpensive.

In using either the camera or the mirror of Sömmering, the eye must be kept exactly in one position; otherwise the image of the object will move. Also the field and the paper must be illuminated to nearly the same extent. One of the screens mentioned at page xxviii is very useful for excluding extraneous light.

Erecting-glass (Lister's). This consists of a brass tube, furnished with a meniscus at

the upper and a plano-convex lens at the lower end. It is screwed into the diaphragm of the body of the microscope, or that of the draw-tube. It erects the images of objects, and serves, with a low object-glass, to reduce the magnifying power at pleasure, and to facilitate dissection under the microscope.

Live-Box and Growing-Slide.—The live-box is an apparatus in which portions of liquid containing infusoria and other small animals or plants can be confined so as to prevent evaporation and allow of their being watched in a living state.

A better apparatus, however, for this purpose is my growing-slide. This consists of a piece of stout plate-glass, 5 inches long and about 2 wide. A circular aperture, of about the diameter of a test-tube, is made near one end ot it. A little glass cup, formed of a portion of a test-tube cut off three fourths of an inch from the closed end, and slightly less in diameter than the aperture, is then fitted into the latter, either by pieces of cork, or by a rim consisting of a glass ring forming a neck to the cup, or in any other way. The cup should project about one fourth above the surface of the slide; and at one portion of its margin a little groove should be ground, in which two or three threads of a lamp-wick can be placed. The cup should be covered with a circular plate of thin glass, larger than its mouth, and prevented from falling off by a disk of cork fitting the mouth and fastened to the plate by marine glue; or the cup may be closed with a common cork, the only objection to this being that the mouth of the cup is apt to split. The manner in which the slide is used is this:—Supposing it is wished to follow the changes undergone by some minute alga or infusorium which has been detected in a drop of liquid, it is placed upon a slide and covered with thin glass; the slide is then placed upon the growing-slide in such manner that the longer dimensions of the two are in the same direction; a little ledge consisting of a strip of glass fastened by marine glue to the growing-slide will serve to rest the slide against, and prevent its becoming displaced. Distilled water, mixed with a small proportion of the water in which the organism was living before being transferred to the slide, is next put into the cup, and a few threads of lamp-wick cotton, thoroughly moistened with distilled water, are then so placed that one end is immersed in the cup whilst the other is brought into contact with the edge of the liquid in which the object is immersed. Thus, as the water evaporates from beneath the thin glass, the threads will afford a continuous supply, and the threads will not become dry until the whole of the liquid in the cup has become absorbed by them and evaporated. In this way we obtain the requisite conditions for the continued growth of aquatic organisms. Care must be taken, however, that the thin glass presses but slightly upon the object, and that the threads come as little as possible into contact with the portions of the slide lying between the cup and the thin glass. If the thin glass cover to the cup fit tightly, and the thread be passed through the notch in the cup, no loss will take place by the direct evaporation of the liquid in the cup. In many cases a modification of this slide is arranged so that organisms can be kept in a warm liquid; this is very useful in examining amœboid movements of the blood-corpuscles, leucocytes, &c. Several varieties of this have been devised (GROWING-SLIDE).

Compressor, an instrument for the regulated compression of a minute object. The same effect can be produced by a well-made live-box, or by pressure directly applied to the thin glass covering an object by the handle of a mounted needle.

Cabinet.—A box or cabinet, containing a number of drawers, will be requisite for holding the objects. Each drawer should be numbered or labelled to facilitate reference. The objects should lie flat in the drawers, so that each may be found when required without

loss of time. The cabinet should be furnished with two folding doors, so as to exclude dust as much as possible. It should also be made of thoroughly seasoned wood, oak or mahogany being the best; if made of deal or cedar, the vapour of the volatile oil of the wood will insinuate itself beneath the thin glass cover and the slide in those objects which are mounted in the dry state, and, condensing upon them and the objects, will obscure and spoil them.

It may be remarked here that the names of objects should always be written upon labels pasted (not gummed) to the slides, not merely upon the slides with a diamond. The colour of the labels should be different for each kind of object; or if the labels be composed of white paper, they should have a coloured margin; thus those of the Desmidiaceæ may be green, the Diatomaceæ yellow, &c., so that the various slides, when accidentally mixed after comparative examinations, can be readily replaced in their respective drawers.

Bell-glasses.—The microscope when in use, either constant or occasional, should always be kept under a large bell-glass, the base of which fits into an annular groove made in a circular flat wooden stand. In this way it is kept from dust, and the trouble and wear and tear consequent upon putting it into a box is saved. Moreover, thus protected, an object under examination can be left without fear of injury or disturbance, and be also preserved from dust.

Several smaller bell-glasses of various sizes should also be kept at hand, under which any objects which it may not be convenient to mount for a time, or the examination of which may not be completed, can be protected.

Slides.—These are ordinarily made of glass about the thickness of common window-glass; their length is usually 3 inches, and their breadth 1 inch. The old length was $2\frac{1}{2}$ inches, which I prefer, as the longer slides, with a large number of objects, take up so much room; but as the aperture in the stage has been enlarged in the modern microscopes to allow of the passage of the parabolic reflector, the Amici's prism, &c., if the old size be retained the slides will drop through the stage: this we remedy by an additional brass plate. Where the objects are very large, the slide must be proportionately large, and its thickness greater than usual. The slides should be made of colourless glass, so as not to interfere with the appreciation of the colour of an object. And they should be flat; otherwise the parts of the object will lie in different planes, and every motion of the slide will require new adjustment of the focus. The edges are best somewhat ground on a copper plate with emery, to prevent injury to the fingers or scratching the stage-plate. Very delicate structures require to be examined and mounted upon thin glass. The slides may then be made of wood, sheet zinc, or tin-plate, with a circular aperture in the middle, upon which a piece of thin glass is cemented; or slides of 9–10-oz. crown-glass may be used.

Covers.—Comparatively few objects can be viewed in the dried state; hence they are most frequently immersed in some kind of liquid. To prevent the evaporation and condensation of this upon the object-glass, and to reduce the thickness of the layer of liquid to a minimum, the object is usually covered with a piece of thin glass. The form of this cover is either square or circular, and the thickness from about the $\frac{1}{50}$ to the $\frac{1}{300}$ of an inch, or even less. These covers are usually kept already cut by the microscope-makers and those who sell objects. Before use, they are best allowed to remain immersed in water for some time. Care is required in wiping this thin glass. It is usually effected by holding the cover at two opposite points of the margin between the finger and the thumb of the left

hand, and rubbing the surfaces with a fold of a cloth, leather, or silk handkerchief covering the same parts of the right hand. But the thinnest glass cannot be wiped in this way without being broken. This requires to be held at the edge by the finger and thumb of the left hand applied to the flat surfaces, and to be drawn slowly through the fold of the cloth in the hand. A very thin layer of mica is useful as a cover with the highest powers, as it prevents the risk of scratching the object-glass, the lower surface of which is often flush with the edge of the brass mounting.

Dipping-tubes.—These are glass tubes varying in length from about 5 inches to a foot, and in calibre from $\frac{1}{8}$ to $\frac{1}{2}$ an inch. They are cut of the proper length by a three-square file, and the ends gently fused in the flame of a spirit-lamp. One end is then coated outside with sealing-wax and spirit, or some other coloured liquid, so that the same end may always be used for the same purpose. They are of use for removing objects from water or other liquids in which they may be contained. Suppose, for instance, it is required to examine some deposit lying at the bottom of a liquid, or an object suspended: the fore finger of the hand in which the tube is held is placed upon the upper end of the tube so as to close it; the other end is then immersed in the liquid and brought into contact with, or as near as possible to the object, and the finger removed from the upper end. Hydrostatic pressure then forces the liquid, and with it the object, into the lower part of the tube, and it can be transferred to a slide. When a tube of narrow calibre is used, the liquid and object are retained within the tube by capillary attraction; they must then be removed by gently blowing at the upper end, the lower end being placed upon the slide. The use of colouring one end of the tube is, that the application of the mouth to the end of the tube which has been immersed in some offensive liquid, as fœtid water, &c., may be avoided.

These tubes should be kept in a glass of distilled water, with the coloured ends uppermost.

When a large tube is used, as in removing the larva of an insect, a tadpole, &c., the quantity of liquid removed is also large, and will be more than is required on the slide. The tube should then be emptied into a watch-glass, and the object placed upon the slide or in the live-box by a camel's-hair pencil.

Forceps are in constant requisition for taking hold of minute objects, dissecting, &c. Those used for medical purposes (common steel dissecting or surgical forceps) are best. There are three points to be attended to in the selection of them. They should not be too short, *i. e.* less than four inches in length at least; the spring- (separating-) action should be very feeble; and the points should be perfectly flat and smooth where they come into contact. If forceps are shorter than the above length, they are not easily held steadily: if the spring-action be strong, on holding an object, as in dissection, with the forceps, the attention being perhaps directed to the scalpel, needle-points, &c., the blades of the forceps separate, and the object escapes from their grasp. If the forceps have teeth or are grooved, perhaps after laying an object out upon a slide under water, or elsewhere, a portion of it becomes entangled in the teeth, and the whole displaced. Surgical "tenaculum-forceps" are very useful occasionally in injecting. These forceps lock by their own spring-action. Supposing, then, the injection is escaping from the orifice of some vessel which has been overlooked and no assistant is at hand, on including the open end of the vessel between the ends of those forceps, which may then be left hanging, it is firmly fixed, and the operator has both hands disengaged to tie it; in fact, these forceps are

indispensable to the injector. They should be short, and not heavy; otherwise the vessel may be torn by their weight.

Surgical "dressing-forceps" are also frequently of use; and long "œsophagus-forceps" with scissor-handles are serviceable for removing portions of plants &c. from large jars or glass vessels.

Needles.—For separating the parts of minute objects, fine points are requisite; these are found in common needles of moderate size fixed by one end into the handle of a water-colour brush. These are easily prepared: the needle is cut in half by cutting-pliers; the blunt end is then forced into the stick, about half an inch in length being left projecting. Surgeons' "cataract-needles" ground down are elegant instruments of this kind, but they require to be shortened. For the minute dissection of objects, the mounted needles require pointing on a hone.

A stout sable-hair or fine bristle, inserted into a slender wooden handle, is frequently of use in isolating minute bodies, as Diatomaceæ, which would be broken by any other instrument. It is used thus: suppose we have a number of *Naviculæ*, or the like, in a bottle, mixed with other bodies, and we wish to isolate one for preservation. A small quantity of the deposit is taken up with a dipping-tube, and allowed to escape upon a slide in such manner as to form a narrow stripe upon it. This is then examined with the lowest power with which the object can be distinguished, and one near the margin of the liquid stripe is selected, and may easily be removed with the mounted bristle (under the microscope) beyond the margin of the liquid. The remainder of the liquid is then wiped away with a cloth, a little distilled water added to the small quantity of liquid left containing the object, and the latter moved with the bristle into the middle of the slide. The liquid is then driven off by heat, and the object is left on the slide ready for mounting. Or, when the matter is dried upon the slide, any one of the minute objects being lightly touched with the dry bristle will adhere to it; and by gently pressing or rotating the bristle upon the middle of a new slide, the object will readily be transferred to the latter. The Diatomaceæ may be easily isolated in this way.

Knives.—Ordinary dissecting-knives or scalpels. The handles should be sufficiently large to allow of being firmly held.

A particular and most useful kind of knife for producing thin sections of soft bodies is that known as "Valentin's knife." It consists of two or sometimes three blades with their flat surfaces parallel, set in a handle. The blades can be fixed at any distance apart, according to the thickness of the section required. It is drawn across and through the substance, from heel to point; the section remains between the blades, and is then removed, either with forceps, or the blades of the knife are opened under water, and the section floated upon a slide immersed in the liquid. In the latter case, the action of the water upon the tissue must not be overlooked. Valentin's knife is absolutely indispensable in the examination of animal bodies. Some sections, especially of plants, are best made with a razor. Many sections can only be made by the aid of the "section-cutter" or microtome, which is described under PREPARATION.

Black and white Disk.—A disk 3 or 4 inches in diameter, made of seasoned wood, and upon one face of which a piece of white paper or card-board has been fastened by paste or glue. One half of the paper or card-board is coloured black; the other is left white. This is very useful in dissecting or separating minute portions of tissues; if these are white, they become much more easily distinguished than usual when placed (on a slide) over the black part of the disk; if they are dark, over the white portion.

Leaded cork.—Some structures require to be dissected under water, as, *e. g.*, those of insects &c. These should be fixed with pins upon a piece of cork, beneath which a plate of lead, corresponding in size, has been fastened. In many cases it is advantageous to dissect these tissues under the simple microscope. An aperture may then be made in the lead and cork, and the tissue or structure stretched across the aperture, so that the light may pass through it; or it may be illuminated as an opaque object by the aid of the bull's-eye.

A trough, composed of five pieces of glass cemented together with marine glue, four for the sides and one for the bottom, will serve to hold the water and the leaded cork.

Evaporating Dish or Saucer.—It is advisable to keep one of these, with a flat bottom, always at hand filled with distilled water, in which slides and covers that have been used may be immersed. The remains of objects which have been examined are thus easily separated from the glasses, and there is but little trouble in wiping the latter clean. If held under a gentle current of water, all remains of tissues or test-liquids may be washed away from the dish—the glasses, from their gravity, remaining at the bottom.

Test-box.—A wooden box, holding from six to a dozen or more test-bottles, is indispensably requisite. The box must be divided into partitions corresponding to the size of the bottles, and the latter must be wedged between these partitions so that the stopper can be removed without fear of disturbing the bottles. The box should be covered with a lid furnished with hinges, so that no room may be required to place the lid when the box is opened. The bottles will vary in size according to option; but they should be of at least 1-ounce capacity. Each should have a stopper so prolonged as nearly to reach the bottom of the bottle, its form being either conical or fusiform. The advantages of this form of stopper are, that a mere trace or several ordinary drops of the reagent may be applied to the object as required. If a very minute quantity be desired, the lower part of the stopper is allowed to touch the inside of the neck of the bottle when it is withdrawn; and if a larger quantity be required, this proceeding may be avoided. Each bottle should be labelled; and a label should also be placed upon the upper end of the side or partition of the box near to the bottle, so that the nature of the contents of each bottle may be ascertained without removing it from the box. The general advantages of this apparatus are, that the quantity of reagent required can be obtained to the greatest nicety, and it can be added to the exact spot required with one hand only, so that the other can be employed to hold the slide and object &c.

Reagents or Test-liquids.—Some of these should be kept in the test-bottles; but larger quantities should also be kept in other stoppered bottles. We give a list here of those test-reagents which are most frequently required; the method of preparing each, the strength, &c. will be found under the respective heads.

1. Sulphuric acid. 2. Nitric acid. 3. Acetic acid. 4. Caustic potash. 5. Chloride of calcium. 6. Aqueous solution of iodine. 7. Oil of turpentine. 8. Glycerine. 9. Acid nitrate of mercury (Millon's test-liquid). 10. Distilled water.

Benzole and alcohol or methylated spirit should also be kept at hand. Chromic acid should be preserved in a wide-mouthed stoppered bottle, and its solution prepared when requisite, as it easily becomes decomposed by dust &c.

Troughs are flat, oblong glass boxes, without lids. They are made of pieces of glass cemented together by marine glue, and are used in examining the larger aquatic plants or animals in a living state, also in mounting objects.

Divided Scale.—A metallic or ivory scale divided into 100ths &c. of an inch, is indispensable in micrometric admeasurements (see MEASUREMENT). The metal or ivory should extend beyond the graduated portion.

Micrometer.—A glass slide with fine lines scratched upon it with a diamond, these being $\frac{1}{1000}$th of an inch apart, is absolutely requisite. Another, with coarser divisions, is also required to be placed in the eyepiece, for making measurements (see MEASUREMENT).

A rectangular *brass table*, with two legs at one end and one at the other, is useful in macerating objects upon slides in chemical reagents, oil of turpentine, or Canada balsam, and in mounting objects. It is heated by a small spirit-lamp placed underneath.

Ring-Net.—A very useful piece of apparatus for collecting Desmidiaceæ, Diatomaceæ, &c., where entangled amongst Confervæ &c., or forming crusts or films upon other aquatic plants, consists of a brass or wooden ring about 4 inches in diameter, furnished with a groove round its circumference, in which also a radial aperture exists, through which the end of a stick may pass. A piece of very fine muslin, rather larger than the ring, is then laid over it, and the margins of the muslin fixed in the groove by means of a vulcanized Indian-rubber band. Or this apparatus may be so modified, that the muslin is fixed by means of an inner ring, adapted to the outer, but incomplete at one point of its circumference, and with a projecting rim to prevent its passing through the outer ring. Thus we have a kind of strainer; and by using several pieces of previously wetted muslin in succession, a large number of the minute organisms may be separated from the water. The pieces of muslin may be brought home, folded up, in wide-mouthed bottles, separately, or several in one, according as the organisms are obtained from one or several waters. In this way we save carrying a large quantity of water. The pieces of muslin are afterwards opened and placed in jars of filtered river-water, and exposed to the light, when the organisms will become detached.

A simple microscope, or some apparatus which will allow of dissection with the aid of lenses, is essential, although the erecting eyepiece or the erecting-glass (p. xxii) will answer the same purpose. It is of little consequence which be selected, provided a large and firm sloping arm-rest be furnished on each side of the stage. Either doublets or the lower powers may be used. Some of the modern simple microscopes are binocular.

Leather Case and Collecting-Bottles.—The Diatomaceæ, Desmidiaceæ, and other smaller Algæ, as also the Infusoria, require to be collected and brought home in bottles. These should be of about 1 or 2 ounces capacity; and, for portability without risk of being broken, they should be packed in a case made of stout leather, with a separate space for each bottle. The whole will pack up in the form of a book.

Having given a sketch of the most important pieces of apparatus, we will say a few words upon the illumination.

Illumination.—The best light in general for microscopic purposes is undoubtedly daylight, or that of the sun reflected from the clouds; and this is certainly the light which can be borne for the greatest length of time without injury to the sight. The position of the observer is of importance; it should be such that the window is on his left hand, or even the back slightly turned towards the window. The advantages of this position are great; for then but little light will enter the eyes directly from the window, and it is of the greatest importance, during a microscopic examination, that the least possible amount of light should be admitted to the eye, from any source, besides that transmitted through or reflected from the object. In drawing also with the camera lucida this position should

be strictly observed; for all extraneous light which would interfere with the distinctness of the image is thus excluded, and the shadow of the pencil and hand does not interfere with or obscure the sketch in progress, which would be the case if the observer's right hand were towards the window. But in daylight the light entering the eye from the window, even in the position above mentioned, will interfere with the observation, unless a preventive be employed, which is to place a screen, either supported upon a stand or fixed to the upper part of the body of the microscope, between the eye and the eyepiece of the microscope and the light. This screen may be made of card-board or thin wood, covered with black velvet. If it be fixed to a moveable arm, like the lens of the side-condenser, it may be easily placed in any convenient position. If to be fitted on the microscope, it may be constructed thus: a piece of stout card-board, of about the size and shape of one of the plates of this work, should have the corners rounded off, and should be bent at a right angle at about the lower one-fourth; a hole being cut in the middle of the smaller portion, of a size just to fit the top of the body of the microscope, a short tube of card-board is then made by sewing or pasting; and this, being fastened in the same way to the circular aperture, serves to keep the screen in position. The whole is then covered with black velvet. When used, the long flap should be placed towards the left side; it then shelters the eye and upper part of the eyepiece from the light. A screen of this kind should always be kept upon the microscope; for it is of the greatest service. A tube made of a roll of card-board, fastened to the inside of the angle of the screen described above, will serve to fix it to the stem of the side-condenser; it may then be made to slide upon this axis or stem at pleasure. It is hardly possible to use the high powers of the microscope by daylight without a screen of this kind.

But few persons have the opportunity of using daylight for microscopic researches, and with the highest powers ordinary daylight is by no means sufficient; hence artificial light of some kind is called into requisition; and the most common source of this is an Argand-lamp (Silber's) with oil; used with or without a side-condenser. For ordinary purposes this answers well, although the best for examining Diatomaceæ &c. is a paraffine-oil or camphine lamp, especially when stops and very high powers and eyepieces are used, whereby a large amount of light is intercepted. A cheap common benzoline lamp with a round or, better, a flat wick, is very advantageous, even with the highest powers ($\frac{1}{50}$th Beale); the direct light being used. In Fiddian's lamp, the flame is enclosed in a metallic case, so resembling a bull's-eye lantern, the light escaping from a round orifice only; hence no extraneous light can reach the eye. The lamp must slide up and down the stem, so that it can be placed at any height; and it should be furnished with a shade, also moveable. A white-cloud earthenware or enamel shade is often used. Norman's paraffine-lamp, and Collin's Bockett lamp, with an attached bull's-eye, and How's lamp, are good lamps. An improved lamp, for illumination and centering with high powers, is described by Dallinger (*M. Mi. Jn.* 1876, xv. p. 165).

Much of the success with which the structure of an object is displayed will depend upon the manner in which the light is thrown upon or transmitted through it. In general the more light that can be condensed upon opaque objects the better; and when the various parts of such objects are of different colours, the more direct the light and the greater the angular aperture of the object-glass, the more clearly will the parts be distinguishable; while in certain opaque objects which present questionable elevations or depressions on

their surface, great obliquity of the incident light is essential. With transparent objects it is sometimes desirable to diminish the amount of light more or less; which may be done, either by means of the diaphragm, by using the flat instead of the concave face of the mirror, or by inclining the mirror to one side. It must not be forgotten, in determining the cause of the better display of an object by the substitution of a less amount of oblique light for a larger amount of direct light, that it need not necessarily arise from the obliquity; for in many instances the cause is simply the diminution of light, whether direct or oblique being a matter of indifference. When the mirror has only one reflecting surface, the amount of light may be diminished by removing the lamp to a greater distance from the mirror, or turning this somewhat on one side. But the difficulty usually found consists in the amount of light being too small instead of too great. This may be overcome by attention to the following circumstances: the mirror must be placed as near the lamp as possible; if it cannot be brought within a few inches of the lamp, the shallow bull's-eye condenser must be made to condense the light upon the mirror: with the object-glasses of high powers the achromatic condenser must be used; and the lower the power of the condensing lenses, the greater will be the amount of light transmitted. The lined appearances presented by many objects, require for their exhibition very oblique light, which may be obtained by first raising the mirror as near as possible to the plane of the stage, and then bringing it as much to one side or the other of the stage as can be done. Nachet's, Amici's, or Reade's prism is very useful for producing the same effect in a greater degree; large angular aperture in the object-glass is also very advantageous under these circumstances, because it will allow of the admission of rays of such a degree of obliquity as could not enter one of smaller aperture.

In cases where still more oblique light is required than can be obtained in any way by reflection from the mirror, this must be turned aside, and the direct light of the lamp used, thus: clamp the slide so that the object projects beyond that side of the stage which is nearest the lamp. The body of the microscope is then rotated so that the object-glass is over the object and fixed by the milled head; the axis of the body being then directed to the light, the object may be thus brought into focus: and by moving the lamp around the microscope, light of any obliquity may be made to pass through the object. This is a simple way of obtaining the most oblique light, and as the light comes directly from the lamp, there is no loss from reflection, as in the use of prisms. By a little variation of this arrangement, the light may be made to fall very obliquely upon opaque objects, especially if uncovered. In many instances the use of the direct light of a lamp is highly advantageous, and may be applied even when the highest powers are used. It has an advantage over that of the mirror, inasmuch as when the latter is used, the light entering the object is derived from two sources, viz. reflection from the outer and the inner surface of the mirror; whereby two images are formed, confusing each other; while with the direct light, the image is single and the definition finer.

Many years ago I suggested a method of remedying the defects of artificial light, or that ordinarily used to replace daylight. The well-known glare attending lamp- or candle-light, and the predominance of a yellow colour, so visible when compared with daylight, render it very unfavourable for microscopic purposes. It was proposed to mix some substance with the combustible which during its combustion evolved a light of the colour complementary to (or forming white light with) that predominant in the artificial light, or to pass the light in its passage from the artificial luminary through a piece

of glass of such colour as to intercept or check the objectionable rays. As these rays are of a yellow or reddish-yellow colour, the colour of the glass must be blue or purplish blue; but the exact shade must be obtained by experiment. Thus: the lamp, or whatever source of artificial light it may be, is lighted in the daytime, and the light transmitted through the microscope by reflection in the ordinary way, when its intensely yellowish colour is very obvious. Pieces of glass of different colours are then separately placed at right angles to the path of the rays from the lamp to the mirror, either close to the flame (in the form of an ordinary lamp-glass), upon the face of the mirror itself, beneath the stage, or in an extra head of the side-condenser. If the glass be of the proper tint, and be placed at the proper distance from the light, and in the proper situation, the field will appear as white as the light of the clouds, which may be easily proved by altering the inclination of the mirror so as to reflect the light of the clouds and the lamp alternately.

It may be remarked that the nearer the coloured glass is placed to the flame the less apparent effect is produced, *i. e.* the more will the yellow colour be perceptible, and *vice versâ.* If the field still appear yellow, the glass is not of sufficiently deep colour; if it appear blue, the colour of the glass is too deep. The first method, or that of mixing some substance with the combustible (oil, tallow, &c.) capable of evolving a light of the requisite tint to form white with the yellow of the artificial light would be far preferable to the latter method; but I am not aware that any experiments have been made to carry out this idea. It would have two great advantages, viz. that there would be no diminution of light, and that the entire apartment would be illuminated by a light equivalent to that of ordinary day. The second method has one objection, which is, that it intercepts a large quantity of the light, so that in the examination of those objects with high powers which require intense illumination, or where much of the light is arrested by stops, it is decidedly objectionable. The advantages which the use of the blue glass possesses are, that it softens the light very much, and that it enables the observer to discriminate between colours as in ordinary daylight.

A few years after the publication of the above method, a patent was taken out for the construction of lamp-glasses of a blue colour; but they are of little service, merely slightly softening the light, or intercepting a small proportion of the yellow rays. Perhaps, some day, a small electric lamp, worked by clock-work, will be invented.

The proper way would be to "flash" the suitably tinted blue glass upon one side of a pale blue lamp-glass, so that, by simply turning the glass round, the light might be transmitted through either of the differently coloured portions. Rainey's "Light-modifier" acts upon this principle. Numerous other pieces of apparatus and ingenious contrivances will be found described and mostly figured in the last edition of Carpenter's 'Microscope,' or in Beale's 'How &c.'

The illumination is of importance to the microscopic observer in another sense, *i. e.* in regard to the injury of sight. The great point here is to avoid too powerful a light. An eminent French philosopher became blind in experimenting upon the duration of powerful impressions upon the retina. In some instances, sun-light has been used in microscopic investigation; the greatest care must then be taken to use screens or diaphragms to temper the light.

II.—GENERAL METHOD OF DETERMINING THE STRUCTURE OF MICROSCOPIC OBJECTS FROM THE APPEARANCES WHICH THEY PRESENT UNDER VARIOUS CONDITIONS.

Microscopic and histological Appearance, Structure, and Analysis.—Before proceeding to this, let us define what is meant by the structure of a microscopic object. If we take a piece of the free end of the finger-nail, and examine a thin transverse section of it under the microscope, we find it to present numerous shorter or longer dark and somewhat irregular lines running nearly parallel to the surfaces. These appearances do not vary essentially whether it be examined in the dry state, or immersed in water or oil of turpentine.

But when it is moistened with solution of potash, and allowed to remain so for some time, or the slide is gently heated, it becomes entirely resolved into a number of nucleated cells; and by watching the gradual action of the potash, it is easily seen that the cells were originally flattened and arranged in layers, which layers produced the lined appearance mentioned above (see the article NAILS). Now which is to be considered as representing the structure of the nail? the first or the second of the above results? Undoubtedly the second. The expressions microscopic structure and histological structure are used very indefinitely, and often synonymously; the former may very conveniently be restricted to signify the apparent structure as determined with the aid of ordinary mechanical means; whilst the latter may designate the true structure in relation to development. It may at first sight appear very unnecessary to make any distinction between the two; but it is really very important, and many of the descriptions of the structure of bodies, given in books, refer only to their microscopic structure.

The determination of the histological or true structure is often very difficult. Frequently a week or a month must be devoted to the determination of a single point. Take the instance of a hard structure—a piece of the skeleton of one of the Invertebrata. A few sections may exhibit cells, laminæ or fibres, according to the preconceived notions of the observer; whilst the histologist will not express an opinion until the inorganic matters have been removed by long maceration in acid, the calcareous salts thoroughly washed away, and attempts have been made to resolve the organic basis into its histological elements by appropriate means. This may require very many experiments to be made, and no mean knowledge of particular branches of science for guidance in the selection of appropriate agents requisite for their performance. We shall have frequent occasion to use the above words in the restricted sense; hence this should not be forgotten. The word analysis will have the same meaning as that generally attributed to it, the ultimate products being morphological.

A general method of determining the structure of objects can hardly be laid down; it must vary so greatly according to the nature of the objects and their size. The first point is to render them transparent, if not already so. This may frequently be done by immersion or maceration, if dry, in water, glycerine, or oil of turpentine. But the solvent power of the liquid must be borne in mind; for the organic principle aleurone was overlooked for years from its being soluble in water, in which the sections of the albumen of seeds containing it were immersed to render them transparent. Sometimes the aid of heat is necessary; and objects may even require to be boiled in these liquids, either upon a slide placed upon the brass table over the flame of a spirit-lamp, or in a small tube. Sometimes

sections require to be made, and these treated in the same manner. If soft, their elements may be separated by the aid of needles; sometimes pressure will answer the same purpose.

When the object is very minute, it will frequently be desirable to examine both sides of it with high powers. Hence it must not be placed upon an ordinary slide, on account of the thickness of the latter, but it must be supported upon, and covered by thin glass. The best plan is to keep a number of slides of thin wood or tin, each having a piece cut out of the middle. A thin glass cover, rather larger than the aperture, should then be cemented by marine glue or Canada balsam to the slide; the thin glass cover is then applied as usual.

If the object be very small and its structure very delicate, it must be crushed, so that some of the fragments may lie perfectly flat upon the slide. See also the article PREPARATION.

The points to be determined in regard to the different parts of an object, however, may be best treated separately.

The examination of a microscopic object must comprise:—*a*, the *microscopic analysis*, including—1, the form; 2, the colour; 3, the structure of the surface; and 4, the internal structure: *b*, *histological analysis*, in the sense already explained: *c*, the *qualitative chemical composition*: and *d*, the *measurement*.

A. MICROSCOPIC ANALYSIS.

1. *The Form.*—*a*. This is usually judged of from the outline as seen by transmitted light, and often erroneously. Where a low power is used, the upper surface of an object and its sides are mostly simultaneously visible; but under a high power, only those parts lying within a very limited vertical range, or in the same plane, are visible at one focus, and the parts lying in planes above or below this can only be brought into view by altering the focus: hence the views of objects under high powers correspond to views of transverse sections of the same objects made through various horizontal planes; and as the margins of objects are usually more distinct by transmitted light than the upper surface, spherical or rounded bodies frequently appear flattened. When several bodies of the same kind are visible in the field of the microscope, some will almost always be found lying upon their sides; and even when the objects are greatly flattened, some will mostly be found lying on edge, presenting the side view.

b. But as there may be uncertainty in regard to the relation of these bodies to each other, the only safe method in forming a conclusion is to cause them to revolve or roll over, so that all their aspects may be distinguished. This is in general easily accomplished: if the object be already immersed in liquid, the inclination of the stage will answer the purpose; or a little benzole, naphtha, alcohol, or some other volatile liquid in which they are insoluble, must be added. The currents produced by the evaporation of these will cause the objects, especially such as are near the edges of the liquid, to move in all directions, and their true form may be discerned. Sometimes moving the thin glass cover sidewise, the object being kept in view, will answer the same end.

c. In figures of microscopic objects, the side view should always be exhibited or described.

d. In the case of crystalline bodies, or such as present angular edges, their angles should be measured with the goniometer, if their chemical composition be unknown.

2. *The Colour.*—The colour of objects should always be carefully described, and its cause accurately determined. It most commonly arises from:—1, partial absorption; 2, the presence of pigment, or other colouring matter; 3, from iridescence; 4, from polarization, &c.

(1.) The most common cause is a peculiar property by which a portion of the coloured rays composing the white light which falls upon or is transmitted through an object is absorbed, the remainder being reflected or refracted so as to reach the eye. On examining bodies thus coloured, with whatever powers, their substance is found uniformly coloured, and this colour is unchanged by their immersion in water or oil of turpentine, and is the same in transparent bodies by both transmitted and reflected light. This is commonly regarded as the *proper colour* of an object. Example: a crystal of blue vitriol.

(2.) *a.* In many cases, however, although an object may appear to the naked eye uniformly coloured, on examining it with a high power, the colour, which in fact arises from the above cause, is seen to be confined to certain molecules or granules, whilst the general substance is colourless. These granules may consist of vegetable or animal colouring-matters, metallic oxides, &c. The nature of these matters should always be determined, if possible, either by microscopic chemistry—micro-chemical analysis, as it has been called,—or by ordinary chemical analysis. When the colouring-matter is of organic nature, and when its composition cannot be determined, or it has no definite name, it is called *pigment.* Objects coloured by pigment, metallic oxides, or other colouring matters, are best examined by direct (not oblique) transmitted light, and when immersed in either water or oil of turpentine. These liquids do not change the colour, nor destroy it unless the pigment be soluble in them; but by rendering the general substance of the object more transparent, they cause the granules to become more distinct. The colour is the same both by transmitted and reflected light. Example: a brown or black hair of an animal, as the mouse.

b. Sometimes bodies coloured by pigment or other colouring-matters appear under the microscope uniformly dyed, although the colouring-matter consists of an insoluble molecular or granular powder—as a white animal hair first macerated in solution of ferrocyanide of potassium and then in solution of perchloride of iron. Chemical means will alone distinguish this cause of colour from the first, by removing the colouring-matter from the colourless basis.

(3.) The colours of many objects vary according to the direction of the light transmitted through them, or are only visible by oblique light, and the colours are different by direct and oblique light. These arise from decomposition of white light by either interference or refraction. For the sake of brevity, these may be designated *colours from iridescence,* because they mostly exhibit the brilliancy and transparency of the colours of the rainbow. The interference or refraction upon which they depend is ordinarily produced by irregularities of structure, frequently depressions or grooves, and sometimes cavities containing air, &c. Objects exhibiting these colours, which are most brilliant by very oblique light and under low powers, when examined with a moderately high power by transmitted direct or but slightly oblique light, frequently appear more dull and less brilliant, often dark or black in parts; and when immersed in oil of turpentine, or some liquid approaching in refractive power the substance of which they are composed, so that their irregularities become filled with it, the colours vanish. Hence colour, when arising from iridescence, can readily be distinguished from that arising from general absorption

or from the presence of pigment; and when the colour of an object obeys the above law, it may be predicted that structural irregularities sufficient to account for its production will be found if properly sought for. Moreover these colours are not the same by reflected and refracted light, and they vanish under very high powers. They may be studied in the species of *Pleurosigma*; and those observers whose microscopes do not magnify sufficiently, or whose object-glasses have not sufficient angular aperture to admit of the detection of the markings upon some of the Diatomaceæ or other bodies of similar structure, may be sure that they are present when these phenomena have been observed. We were thus led to search for them upon the valves of *Melosira varians* and *Borreri*, species of *Nitzschia*, &c., where they had not been previously detected; and there they are present. Again, the colours of the dried valves of the Diatomaceæ, many of which have a brown tinge, have been supposed to depend upon the presence of the peroxide of iron; but as this colour vanishes when the valves are immersed in oil of turpentine, independently of the fact that the valves do not present the same brown colour by reflected and transmitted light, and by direct and oblique light, which we have stated to be characteristic of the presence of colouring-matter, the colour cannot arise from this cause.

An example of iridescent colour arising from the presence of fibres, is found in the tapetum. Certain cases, referable to this head, require special notice. Thus it sometimes becomes a question whether a very minute red spot, visible in an Infusorium, Alga, &c., is the optical expression of a minute vacuole, or a little depression filled with water, air, or other fluid of less highly refractive power than the substance of which the organism consists, or whether it arises from the presence of pigment. The point is easily decided: a practised eye will recognize the transparency of the colour where not arising from pigment, and its granular appearance where the pigment is present. If the substance of the object be soft, compression will frequently destroy the appearance when pigment is absent. Drying the object and then immersing it in oil of turpentine or other highly refractive liquid will do the same, whilst pigment will become even more distinct if present. Moreover, on altering the focus of the object-glass, the colour will be found to change, when not arising from pigment.

The colours of thin plates are so rare in microscopic objects, that we must refer to works upon optics for an account of them. They occur in the crystals found upon the surface of the scales of various fishes, the eggs and wings of insects, &c.

(4.) The colour arising from polarized light is noticed under ANALYTIC CRYSTALS, DICHROISM, and POLARIZATION.

The colours of objects examined by transmitted light are frequently rendered much darker, and colourless or coloured objects may appear dark or even quite black, from refraction or reflection of the light out of the field of the microscope. Thus powdered vermilion appears almost black; air-bubbles appear black at the margins or entirely black, &c.: hence the importance of comparing observations made by both reflected and transmitted light; for neglect of this precaution caused the air in the hairs of animals to be mistaken for pigment. Milk-white opacity mostly arises from the presence of numerous molecules, granules, thin layers of liquid or other surfaces which reflect a large quantity of the light incident upon them, as in milk—where the reflecting bodies consist of the globules of fatty matter (butter),—white paper, tubercle, &c.

3. *Structure of the Surface.*—*a.* When an object is of comparatively large size, the

structure of the outer surface is in general easily determined by examining it with reflected light, *i. e.* as an opaque object illuminated by the Lieberkühn or side-condenser; but when the objects are small, sufficient light cannot be thrown upon them with ordinary condensers; recourse must then be had to the opaque reflectors mentioned at p. xxi.

b. The appearances presented must also be controlled by those resulting from the action of transmitted light. And here we meet with a difficult task, in accomplishing which, the following questions are constantly presenting themselves:—Do certain spots, lines, or other markings visible upon the surface represent elevations or depressions? Are they cavities in the outer portion or layer of the object? Are they foramina or holes? Are they granules of pigment, or rows of them? Do the lines represent a true lined structure, or are they optical illusions? Is the surface smooth and free from markings? The methods of answering these questions must vary so greatly, according to the nature of the object, its size, &c., that it would be almost impossible to lay them down by rule. The following considerations, however, are of most importance.

c. In many cases where structural appearances are visible at the surface of an object, their true situation above or beneath the surface may be determined by raising the object-glass above the focus of the surface. On then carefully and gradually depressing the object-glass with the fine movement, the structure first brought into focus is the uppermost. Thus, the inner surface of the under membrame of the elytrum of the stag-beetle (*Lucanus cervus*) is covered with very minute hairs projecting from the surface (Pl. 34. fig. 2). On placing this with the inner side uppermost and adjusting the object-glass as just described, the hairs are distinctly brought into focus before the surface of the membrane. Hence they are situated upon the surface; whereas, had the surface of the membrane been brought into view before the hairs, it must have been concluded that the latter were situated on a plane below this. It may be stated that the surface of a membrane is recognized to be in focus by certain irregular granules, molecules, or wrinkles mostly visible upon it.

d. Frequently, when hairs, filaments, or spines project from a surface, their relative position may be determined by examining the margin of the object if it be rounded, or the margin of a fold if it be flat and membranous—as in the case of ciliated bodies, Infusoria, &c.

e. Cilia upon the surface of an object are sometimes so minute and transparent as to be with difficulty detected; they can however always be made evident, when present, by the following means:—1. Drying the object; they then become much darker from refraction. 2. Dyeing the object with solution of iodine; drying the object after the addition of the latter solution is sometimes advantageous. 3. Mixing insoluble coloured particles, as those of lampblack, or Prussian blue, with the water in which the objects are contained; of course this is only of use if the objects be living; the particles will then be set in motion, and their motion may be distinguished from molecular motion by the definite direction in which the particles move.

f. The nature of many markings, spots, &c. in transparent objects is best determined by Dujardin's method, viz. that of comparing at different foci the effects of the refraction of the transmitted light produced by the markings themselves, and the substances in which they are situated; and these phenomena may be conveniently illustrated by their occurrence in known objects. If a drop of oil of turpentine, which has been digested with alkanet root so as to become coloured, be placed upon a slide, a drop of water added to it, a thin

glass cover applied, and the cover be moved backwards and forwards upon the slide with the finger covered with a cloth, the drop of oil will be subdivided into globules of various sizes, some of which will enclose globules of water; thus we shall have globules of the oil surrounded simply by water, globules of water enclosed in globules of oil, and some of these globules will contain within them globules of the other kind again, the globules of oil being readily distinguished by their red colour. On examining the slide with a tolerably high power, all the globules will appear bounded by a black circle, and present a luminous point in the centre, when viewed separately and the focus suitably adjusted for each. But when they are examined in comparison and together, they will be found to exhibit characteristic appearances according to the variation of the focus. Thus, of the simple globules, when their margin is most distinctly brought into focus, some will become more luminous as the object-glass is depressed (Pl. 49. fig. 1 *a*)—these are globules of water surrounded by oil; others will become darker under the same circumstances (Pl. 49. fig. 1 *b*), and very luminous as the object-glass is raised (Pl. 49. fig. 1 *c*)—these are globules of oil; and the nature of the components of the compound globules may easily be determined by the occurrence of the same phenomena. The globules of oil being more highly refractive than the water, act like little convex lenses; whilst the globules of water surrounded by the oil, exerting a lower refractive power than the latter, act like concave lenses, and their centre appears luminous because the rays which traversed them diverge as they ascend, as if they emanated from a (virtual) focus situated beneath the globules, or on the same side of them as the mirror. Hence these foci may be distinguished as the "lenticular foci" of the objects. And when dots or markings upon objects are very minute, frequently all that can be distinguished under the microscope are these lenticular foci of the various parts.

The same phenomena may be observed in air-bubbles immersed in water; these correspond with the globules of water surrounded by the oil. It need scarcely be remarked that the object in colouring the oil is to allow of the control of the conclusions arrived at.

g. In the globules of sarcode or protoplasm and many cells, the vacuoles are easily shown, by the same method, to be filled with a material of less refractive power than the general substance of which they are composed: these vacuoles are frequently mistaken for nuclei and nucleoli; but they are readily distinguished from them by the dark appearance they present when the object-glass is raised above the focus of their margins.

h. The above principles are applicable to the determination of numerous cases where the elevation or depression of a spot or marking upon a surface is called in question; for elevations on a surface will produce the general effect of convex lenses, whilst depressions will produce that of concave lenses. In the above experiment, plano-convex lenses of both oil and water are frequently seen, and readily distinguished by the above means.

Take also the instance of a *Paramecium aurelia*, either dried or immersed in water. The surface is beautifully marked with pretty regular dots, which appear luminous as the object-glass is depressed (Pl. 32. fig. 1 *a*), and dark as it is elevated (Pl. 32. fig. 1 *b*); hence they consist of depressions upon the surface. Had they been elevations or little tubercles, they would have become more luminous as the object-glass was raised, and *vice versâ*.

When an isolated granule of pigment or of any opaque substance is brought into focus, on raising the object-glass a luminous spot appears to occupy its place; hence it agrees so far with a highly refractive granule. The appearance, however, arises from diffraction,

and may usually be distinguished from that produced by refraction by the luminous spot equalling or exceeding the granule in size, whilst in the latter it is smaller and more brilliant.

i. In all these experiments the less oblique the light the more certain will be the results. But this method is inapplicable to decide whether the less refractive portions are simply depressions or cells. This may often be determined by examining the margin of the object where possible (as in *Paramecium*), and observing whether there are depressions upon it corresponding to the parts at which the dots are situated, and whether these depressions are continuous with the dots (Pl. 32. fig. 1 *b*). When the substance of the object is somewhat firm, drying it, if moist, will cause the dots to become filled with air: they will then, if cells, appear infinitely blacker than if simply depressions, and visible as readily by direct as by oblique light; and after the object has been moistened with water or oil of turpentine, if it be immediately examined, the blackness of the dots will appear still greater, and they will be distinctly visible by direct light; whilst depressions are much more easily filled with liquid, and then, if minute, will only be visible by oblique light.

In relation to this matter, the meaning of the "optical section" of minute objects viewed under the microscope is important to be considered. Taking a globule of oil, or a pollen-grain, and bringing the object-glass to focus upon the upper surface, at first the portion of the surface which is in focus is visible; on lowering the object-glass, the surface becomes invisible or indistinct, while a portion of the margin comes into focus, forming a ring. This enlarges until the most convex portion is reached, when it diminishes until the lower portion of the globule or grain is visible. In this way we obtain the same views of the object, as if so many transverse sections or planes were examined. The better the corrections of the object-glass, and the larger the angular aperture, the more distinctly will these phenomena be developed.

k. If it can be shown that the parts corresponding to the dots are depressed below the general surface, and the dots or depressions present an angular outline, these dots cannot possibly represent cells, because, if the angularity of the outlines of cell structures arose from the pressure of surrounding or adjacent cells, this pressure would necessarily be exerted also upon the free or external portion of each cell, so as to render it convex, or at any rate not concave. The firmness of the substance of the object must be attended to, because, where it is absent, as the cells part with the liquid portion of their contents the outer portion of the cell-wall may become approximated to the inner, and thus no space be left for the air to enter, as in the exuviæ of a *Triton* for instance.

l. In brittle objects, as the siliceous valves of the larger Diatomaceæ, the examination of the margins of crushed and perfectly flat portions is important and sometimes conclusive; for it may be found, as in *Isthmia* (Pl. 17. fig. 2 *b*) &c., that the depression of the object-glass requisite to bring into focus the margins of the thin depressed portion is much greater than that required for the intermediate thicker parts. In the valves of the more delicate Diatomaceæ (*Pleurosigma* &c.), in which this observation is difficult to be made, the point is important that the line of fracture of the broken valve passes through the rows of dark dots or the lines corresponding to them, showing that they are thinner and weaker than the rest of the substance; had these dots represented elevations, the valves would have been stronger at these parts. The nature of the markings upon the siliceous valves of the Diatomaceæ, especially the species of *Pleurosigma*, has long formed a disputed point. In distinguishing in general minute points, as the little siliceous spines of the cuticle of *Equi-*

setum, the very short spines on the wings of many insects (*Tipulidæ* &c.), or the minute spheroids in Schultze's siliceous films, it may aid somewhat to remember that prominences are usually most distinct under open central illumination, while depressions are most evident under the central-stop illumination. If we take a flat fragment of an *Isthmia*, and examine it by the aid of the condenser with a central stop and an object-glass of lower power, care being taken that the condenser and stop are perfectly central, it will exhibit a series of angular dark or black dots bounded by luminous lines separating them (Pl. 15. fig. 47), and this when all parts of the object are best in focus; for when the object-glass is elevated or depressed, the whole becomes indistinct. The black dots in this instance clearly coincide with the depressed portions of the surface of the valve. The same phenomena may be observed in many other Diatomaceæ, as *Triceratium* (Pl. 17. fig. 29), *Coscinodiscus* (Pl. 51. fig. 1), &c. But when we examine those which have very fine markings, as the valves of *Pleurosigma* (Pl. 15), the appearances vary greatly, according to the method of illumination. The dark lines (Pl. 15. figs. 10, 12, and 25), which are brought to view by oblique illumination, correspond to the rows of the black dots of *Isthmia* (the thinner and weaker portions of the valves), and with stop-illumination are resolved into the separate dots (Pl. 15. fig. 40), the rest of the valve appearing white and uniform. But at a different focus, especially under immersion-lenses, the white portions of the valve present the appearance of rows of bright pearls (Pl. 15. fig. 46), the other portions of the valve appearing dark. The same brilliant pearls are seen in the finer valves of *Coscinodiscus* with the open central illumination. The article Diatomaceæ must be consulted for further details in regard to the structure of these valves, and the article Angular Aperture in regard to the changes produced in the appearances of objects by variation of the angular aperture of the object-glass, and of the degrees of obliquity of the transmitted light. But we may remark here that these dots must not be compared to cells, but to the depressions found upon the seeds of the white poppy, *Paramecium*, &c., in which forms resembling those resulting from the mutual pressure of adjacent cells are present, but do not arise, so far as we know, from this cause.

m. No special remarks are required in regard to furrows, as these are only elongated depressions.

n. When ridges are present, these are frequently left projecting at the margin of a fragment; sometimes they project naturally; and it may readily be known that they are thicker portions of structure, by their blacker margins and their exhibiting the characters of elongated convex or plano-convex lenses.

In some cases, the position assumed by confined portions of air, when the object is immersed in liquid, will denote the existence of ridges. Thus we have seen portions of air, accidentally confined between the surface of a scale of *Lepisma saccharina* and the thin glass covering it, assume an elongated form, being limited laterally by the ridges upon the scale (Pl. 34. fig. 3).

o. Foramina or holes are in general readily distinguished by their dark and defined margins, and the absence of colour when they exist in coloured structures; when existing in transparent colourless objects, the latter mostly exhibit minute irregularities, by which the presence of some kind of matter is indicated, whilst these are absent in the foramina. Where there is difficulty in deciding, the structure should be broken, if possible, and the margins examined. Sometimes the polariscope is of use: the general substance may

polarize light; but of course the foramina will not do so. Charring the structure, or colouring it with reagents, if organic, will sometimes afford decisive proof.

Foramina cannot be mistaken for elevations on the surface, because they do not become more luminous as the object-glass is raised after their margin has been brought most distinctly into focus; in fact the reverse occurs: hence they so far agree with depressions; but they differ from these in their luminous appearance with high powers, and their not being rendered more distinct by oblique light, but the reverse.

p. When the structure in which they are situated is somewhat thick, and they form rather tubes than foramina, as the axes of these can hardly coincide with the direction of the transmitted light, their orifices will appear dark or black; hence they might be mistaken for granules of pigment: immersion or maceration of the structure in oil of turpentine, however, will fill them, and cause the dark appearance to vanish, whilst pigment would still be visible. Examination by reflected light will also readily distinguish the one case from the other. Also where this tubular structure is present, perpendicular sections will exhibit furrows, which may be recognized as directed above. In distinguishing foramina, the higher the power employed the less is the difficulty.

q. It has sometimes to be decided whether certain dark lines visible at the surface of objects, represent ridges or grooves, or whether they are illusory shadows arising from the passage of light through a structure furnished with depressions, granules of pigment, &c. This must be done by examining the object when illuminated by reflected light, or a hollow cone of oblique rays, such as is obtained on using the achromatic condenser with the central stop; when thus illuminated, the lined appearance will vanish, and the true structure will become visible.

r. It often happens that objects, especially highly refractive bodies, appear surrounded or covered by a number of black lines, rings or annular lines, arising from diffraction, and it becomes an important question whether these lines represent cell-walls, rows of dots, &c. When they arise from diffraction, they vary in number according to the obliquity of the incident light and the angular aperture of the object-glass; and when the condenser is used, they vary according to its adjustment, and at a particular adjustment they will sometimes disappear entirely. Hence in these cases the condenser should always be used, and the results obtained controlled by the effects of immersion in highly-refractive liquids, and the means mentioned below.

s. A very ingenious method has been proposed and adopted successfully by Wenham, for exhibiting the form of certain very minute markings upon objects. A negative photographic impression of the object is first taken on collodion in the ordinary way, with the highest power of the microscope that can be used. After this has been properly fixed, it is placed in the sliding frame of an ordinary camera, and the frame-end of the latter adjusted into an opening cut in the shutter of a perfectly dark room. Parallel rays of sun-light are then thrown through the picture by means of a flat piece of looking-glass fixed outside the shutter in such a manner as to catch and reflect the rays through the camera. A screen standing in the room, opposite the lens of the camera, will now receive an image, exactly as from a magic lantern, and the size of the image will be proportionate to the distance. On this screen is placed a sheet of photogenic paper intended to receive the magnified picture. A portion of the valve of a *Pleurosigma* magnified in this manner is represented in Pl. 15. fig. 41.

4. *Internal Structure.*—We must be understood here as referring to the general structure

of an object, *i. e.* whether it is solid or cellular, &c.; and where an object is composed of an aggregation of similar parts, our remarks must be applied to these individually.

The first question arising is whether a transparent object is solid or semisolid and homogeneous, or whether it represents a cell, *i. e.* has an outer membrane or cell-wall and contents of a different nature. When objects possess an outer coat, its two margins are sometimes easily distinguishable on examination by transmitted light, especially when its thickness is considerable. But when the outer coat is thin, these are difficult to distinguish; recourse must then be had to other means than simple inspection; and these will vary according to the nature of the object, and especially the softness of its cell-wall. Sometimes crushing it may show clearly that the contents consist of a liquid with numerous molecules and granules, and that the cell-wall is thin and membranous; for the subsequent addition of water may separate and render both distinct. The most valuable test-method, however, is the production of endosmosis or exosmosis. If we take a cell with a soft and thin wall, and add distilled water to it, it will imbibe a certain quantity of it and become distended, and often the contents will become distinctly separated and visible within; whilst if a saturated solution of some salt, as chloride of calcium, be added, it will become wrinkled and collapsed. On treating a solid or homogeneous body with water, it remains unaltered, or perhaps swells slightly; but on treating it with the solution of chloride of calcium, no wrinkling or contraction occurs, and its appearance is unchanged. If the outer coat be firm and resisting, the chloride will not cause it to contract and wrinkle.

If there be two coats, the outer being firmer than the inner, the latter will be wrinkled and collapsed, while the former retains its shape; this is the ordinary occurrence in young vegetable cells. The exosmotic effects of the chloride of calcium should be looked for soon after its addition to the object, particular care being taken that it comes into contact with the object; for when solid or semisolid bodies are macerated for a long time in the saline solution, they will become contracted, and globules of sarcode will escape from them; but we believe that in all these cases there really exists a cell-wall, or a structure corresponding to it; hence by solid or semisolid bodies, we must be understood to mean those which differ from cells according to the characteristic action of exosmose.

It must be remembered that solution of chloride of calcium is a highly refractive liquid; hence it frequently renders globules so transparent that they are almost or completely invisible, and thus apparently dissolves them; sometimes also it really dissolves them. Moreover many so-called unicellular vegetable organisms exhibit the contraction of the internal cell-wall or primordial utricle, from long maceration in water only, as is so frequently seen in the Desmidiaceæ "mounted" in water. An aqueous solution of iodine is also frequently useful in bringing to light the existence of an inner cell-wall, especially in vegetable structures, causing it to become wrinkled and collapsed.

Cells have not the tendency to fuse together or adhere to each other, which globules of sarcode or other glutinous solid or semisolid substances have.

If the object be brittle, crushing it will sometimes show its internal structure, by allowing the examination of the margins of the fragments.

Spherical or rounded solid bodies, when immersed in water or other liquids of low refractive power, generally present a much less distinct black margin than cellular bodies, or those with membranous walls.

The determination of the contents of an object furnished with an outer coat, must be made according to the foregoing indications. The contents often consist of liquid in which

are suspended molecules and granules. If these exhibit molecular motion, the material in which they are suspended must be liquid. It sometimes becomes a question whether a body enclosed within another is central or lateral. This is readily determined by causing the body to revolve by inclining the stage of the microscope, when, if central and fixed, the enclosed body will retain this position; and if it be less than the cavity of the enclosing structure, positive indication will be afforded that the latter is solid, or at least that it does not consist simply of an outer coat with liquid contents and the enclosed body. But if it be attached to the inner wall of the enclosing structure, the eccentricity of its motion whilst revolving will be evident.

The contents of microscopic bodies are frequently rendered distinct by the addition of reagents, and in some cases can only be distinguished by their use; thus the nuclei of animal cells are at once made evident by the addition of acetic acid, &c.

The micro-spectroscope is often used in detecting small quantities of different substances (SPECTROSCOPE).

We frequently have to decide whether the interior of an object is solid or tubular. If it consist of a firm substance, drying it, if in liquid, will cause the evaporation of the liquid or other contents, and the entrance of air. A section of it will also show whether it is solid or hollow. The effects of crushing it should also be observed.

An important aid in describing the structure of many objects, the components of which are of so nearly similar refractive power as to be undistinguishable by any variation in illumination, is that of dyeing or staining. Different portions of a structure often have a variable affinity for colouring-matters or dyes, and can thus be readily distinguished. The various appropriate dyes are mentioned under the tissues, and the process under STAINING.

B. HISTOLOGICAL ANALYSIS.

This consists in the resolution of the object into its component morphological elements, and is usually effected by subjecting it to the action of various chemical reagents, continued maceration, &c. It must never be attempted if inorganic matters be present in quantity, until these have been previously removed. The reagent used should be one which exerts a solvent action upon the substance of which the object is composed, the action being interrupted at a certain stage by the addition of water, &c. In regard to those objects whose morphological elements have become altered by individual growth, &c., histological analysis is of course useless, and the manner in which these have acquired their existing structure can only be determined by tracing the gradual changes which their morphological constituents undergo, from the earliest period of their existence to that at which they form the object in question. This constitutes the study of development; or it might be termed Histological synthesis. It can rarely be followed directly, but may often be carried out indirectly by examining a number of the objects in all stages of their development, and comparing the changes undergone by their constituents. It requires special care in controlling the identity of the objects.

C. CHEMICAL REACTIONS.

We cannot too strongly insist upon the necessity of investigating these in the case of all objects submitted to examination, the nature of which is at all doubtful—and this because in many instances the form or general appearance will afford no criterion by which the nature may be determined. Judgment founded simply upon the form, or upon the

mere inspection of an object, therefore, will illustrate the abuse and not the proper use of the microscope. The quantitative and ultimate analysis of substances cannot be made in any manner by the aid of microscopic manipulation; but the qualitative analysis, or the study of the action of chemical reagents upon the object or substance by the aid of the microscope, or micro-chemical analysis, may be undertaken with the prospect of almost certain success, in most cases at least, in ascertaining the proximate chemical composition.

The characteristic reactions or tests for the various proximate principles are given in this work under the respective heads of those substances; and we can here give only a brief sketch of the manner in which the micro-chemical analysis of a substance may be conducted, and without which its microscopic investigation must be imperfect and of little or no value.

The first point to be attended to is, to ensure, as far as possible, the freedom of the object from foreign admixtures. Thus, if it should have been found in an animal or vegetable liquid, it must be carefully washed, either in a watch-glass or upon a slide whilst covered with thin glass. The former is readily accomplished: the substance being placed in a watch-glass, water or other solvent of foreign matters is added; the whole is then set aside, to allow of the subsidence of the substance, and the supernatant liquid removed by a pipette. If the body or the particles be very minute, it or they must be placed upon a glass slide, and covered with thin glass; the latter should then be pressed, so far as is possible without crushing the particles, but sufficiently to fix them, and a small piece of coarse white blotting-paper placed upon the surface of the slide, so as to touch the edge of the liquid; capillary attraction will cause the liquid to be absorbed by the paper. Small quantities of water, or other proper solvent, are then added by small portions from the end of a glass rod to the *opposite* edge of the liquid confined by the thin glass. Thus a current will be set up, and the newly added liquid will be absorbed by the blotting-paper, washing in its course the particles confined between the two glasses. The current will be regulated by the quantity of liquid added, and the facility with which the paper absorbs it.

When the body has been washed, the effects of the various reagents may be examined, by the addition of them in small quantities from the conical stoppers of the test-bottles (see *Test-box*, p. xxvii). The test-liquid being applied to the edge of the liquid in which the body is immersed, gradually mixes with it, and the effects produced may be watched step by step. If a solvent or other action is seen to take place, the result is decisive; but if no action be evident, it must be remembered that the reagent added may not have reached the object under examination, perhaps from an insufficient lapse of time for the occurrence of diffusion in the two liquids. To be positive, therefore, that the reagent has no action upon the object when none is at first apparent, as much as possible of the liquid in which it is immersed should be removed by blotting-paper; or the liquid be gently driven off by evaporation; or, if the object be of sufficient size to ensure its not being lost, the thin glass should be removed, and the whole, or as much as possible, of the liquid removed either by the blotting-paper or evaporation. On then covering the object with the thin glass, and adding the reagent to the edge of the latter, there can be no doubt of its coming into contact with the body; and the result may be considered decisive.

Where the combined effects of a reagent and heat are required to be observed, the former may be added as usual, and the slide placed upon the brass table mentioned at p. xxviii

until the liquid boils, or the requisite amount of heat has been applied,—the object of course being covered by thin glass. The slide must then be allowed to become perfectly cold before being placed under the microscope; otherwise the heat might melt the balsam with which the lenses of the object-glass are cemented together. The cooling is much facilitated by placing the slide upon a plate or surface of metal; we generally use the foot, or a part of the stand, of the microscope for this purpose.

The effect of a red heat is sometimes very desirable to be tested. This may be accomplished by exposing the object, placed upon a strip of platinum foil, a piece of thin glass or of mica, to the flame of a spirit-lamp. The odour evolved should be noticed. If this be ammoniacal, or resemble that of burnt horn, the body, if not crystalline, is probably of animal nature, and certainly contains nitrogen.

If the body consist solely of inorganic matter, or of oxalates, it will not be blackened by the heat. If it consist partly of inorganic and partly of organic matter, it will be blackened, and the inorganic matter will be left in the form of an ash. The alteration produced in the form of the object by the heat should also be noted.

In applying a red heat to a substance upon thin glass, the whole of its moisture must first be expelled by evaporation; otherwise the glass will certainly crack, and the experiment be spoiled. The strip of platinum may be held by forceps; and the thin glass or mica, upon a curved piece of iron wire. We can here add only a few of the reagents the action of which it may be most desirable to obtain in determining the nature of a doubtful body. Further particulars will be given under the heads of the various reagents, principles, and tissues, in the body of the work.

1. *Solution of caustic potash* (especially when heated).—The cell-walls of plants are not greatly affected; they retain their primitive form, only becoming somewhat swollen, whilst animal substances are mostly dissolved; chitine, however, is unaltered. The solution also possesses a remarkable power of separating many animal structures into their component cells, &c. When cold, it separates proteine compounds from fatty matters, &c. It also removes the foreign compounds with which the cellulose of the epidermal structures of plants is often imbued. Its action has been proposed to distinguish an animal from a vegetable organism, and will yet probably prove to be of value in this respect.

2. *Solution of iodine* (in water) dyes most animal and vegetable substances brown; renders also lime brown; colours starch, certain cell-walls of vegetables, amyloid, the amylaceous bodies of the human brain, &c. blue.

3. *Sulphuric acid*, when added to the external coat or cell-wall of plants (cellulose) dyed with iodine, renders it blue or purple (Pl. 7. figs. 1 *c* and 3 *c*). In a few instances, however, where cellulose exists in animal tissues, the same blue colour is produced; but in these there is real animal matter also, recognizable by its appropriate tests. When added to bile or proteine compounds mixed with solution of sugar, it renders them red (Pettenkofer's test). If the body contain lime (except already as sulphate), the acicular crystals of the sulphate (Pl. 10. fig. 16) are produced.

4. *Muriatic acid* with heat colours the proteine compounds.

5. *Acetic acid* brings into view the nuclei of animal cells and tissues, dissolves many salts, &c.

6. *Dilute nitric acid* (20 per cent.) coagulates albumen, renders unstriped muscular fibre-cells very distinct, &c. Strong acid by boiling removes all but the cellulose from woody fibre.

7. *Millon's test-liquid* for proteine compounds. (See MILLON'S TEST.)

8. *Ether* or *benzole* dissolves fatty and resinous matters, &c.

9. *Chromo-sulphuric acid*, or a mixture of solution of bichromate of potash and excess of sulphuric acid, dissolves the intercellular substance of plants, thus isolating beautifully the wood-cells &c., and developes the starch-rings &c.

10. *Ammoniuret of copper*, formed by digesting copper turnings in an open bottle with solution of ammonia, rapidly dissolves cellulose. It must be used fresh.

11. *Dye-tests.*—Carmine and ammonia, or the aniline-compounds, Judson's dyes, magenta, picro-carmine, logwood, chloride of gold, picric acid, &c. are often used as such (STAINING).

These are perhaps the most common reagents which the experimenter will be called upon to use. A general plan for the qualitative analysis of substances must be obtained from works upon chemical analysis. It may be remarked, however, that the qualitative analysis of portions of a substance too minute to be more than barely discerned by the naked eye, may be effected by the aid of the microscope. The use of the microscope in strictly chemical investigations also, cannot be too highly recommended; for it will frequently throw great light upon the distinction of chemical precipitates of closely approximative chemical properties.

D. MEASUREMENT.

A knowledge of the size of objects is of the utmost importance, and is frequently of great assistance in the distinction of one object from another; for many objects of totally dissimilar nature present exactly or nearly the same appearances when examined with different powers. The dimensions should invariably be added to the description of microscopic bodies; and when figures are given, the number expressing the linear amplification of the objects should be placed near them.

Directions for determining the measurement of objects are given under the head MEASUREMENT. It should always be expressed in fractions of an English inch.

In conclusion, we must remark that the observations given in this Introduction are not offered as by any means complete. However, we trust they will serve to show that there are numerous means at command for determining the structure of objects, to indicate the nature of these means, and that microscopic researches should be carried out upon something like a definite plan.

MICROSCOPIC ANALYSIS.

The following list of miscellaneous matters, forming an analysis of the second part of the Introduction, may serve to recall to the observer the most important points to be looked for, and the means of discovering them.

MICROSCOPIC ANALYSIS. Form :—*a, outline*; *b, rolling over*; *c, side view*; *d, end view*; *e*, angles, *goniometer*.

Colour :—1, General colour, true colour ; 2, pigment ; *a*, partial from pigment ; *b*, general colour from pigment ; 3, iridescence, thin plates ; air-bubbles, &c., *immersion in highly refractive liquids, action of transmitted and reflected light* ; *compression* ; polarization, &c.

Surface :—*Reflected light* ; projections ; cilia, *margin, iodine, desiccation, fine particles* ; hairs, crystals—upon or beneath the surface ; tubercles, ridges, folds, *side view* ; *effects of altered focus* ; *fracture* ; *foramina, polariscope* ; illusory lines, diffraction ; depressions, circular, angular ; furrows ; tubules ; cells ; *oblique light, stops in condenser.*

Internal structure and contents :—Homogeneous ; cell-wall, *endosmosis, exosmosis, chloride of calcium* ; *adherence* ; *margin, crushing, molecular motion* ; granules, nucleus—central, excentric ; *reagents, acetic acid* ; *nucleolus*, vacuoles.

Histological analysis.—*Reagents* ; *maceration, development.*

Micro-chemical analysis.—*Washing* ; *heat* ; *red heat, odour, ash* ; *reagents, contact with reagents* ; *potash, ammoniuret of copper, iodine, sulphuric, chromo-sulphuric, muriatic, nitric, acetic acids* ; *Millon's test* ; *sulphuric acid and syrup* ; *sulphuric acid and iodine* ; *ether or benzole, &c.* ; *dyes.*

Measurement.—In fractions of an English inch (not line nor foreign measures).

Bibliography.—Microscopes, Apparatus, and Observation. Quekett, *Microscope*, 1853 ; Brewster, *Treat. on the Microscope* ; Ross, '*Microscope*,' *Penny Cyclopædia* ; Dujardin, *Observateur* ; Mandl, *Traité prat. du Microscope*, 1839 ; Chevalier, *Traité d. Micr. &c.* ; Tulk and Henfrey, *Anat. Manip.* ; Mohl, *Micrographia*, 1846 ; H. Schacht, *Das Mikroskop* (Currie, 1853) ; Harting, *Het Microscoop* (and the German translation, *Das Mikroskop*, 1866) ; Carpenter, *The Microscope*, 1881 ; Goring and Pritchard, *Microsc. Cabinet*, 1832 ; Hannover, *The Microscope* (transl. by Goodsir), 1853 ; Heller, *Das dioptrische Mikr.*, 1856 ; *Journal of the Microscop. Soc. of London* ; *Monthly Microsc. Journ.* (to 1877) ; *Quart. Journal of Microsc. Science* (passim) ; Reinicke, *Beiträg. z. Mikrosk.*, 1863 ; R. Beck, *Treatise on Achromatic Microscopes*, 1865 ; Frey, *Das Mikroskop &c.*, 1881 ; Nägeli u. Schwendener, *Das Mikroskop* (*Mathematics*), 1877 ; Reinisch, *D. Mikr.*, 1867 ; Wiesner, *Einleitung &c.*, 1867 ; Hager, *Das Mikrosk.*, 1876 ; Dippel, *Das Mik. &c.*, 1867–71 ; Chevalier, *L'Etudiant Micrographe*, 1872 ; Robin, *Le Mic.*, 1877 ; Wythe, *Microscopist*, 1877 ; Duval and Lereboullet, *Man.* (*clinique*) *d. Micr.* 1880 ; Pelletan, *Mic.*, 1880 ; Beauregard and Galippe, *Microgr.*, 1880 ; Thanhoffer, *D. Mik.*, 1880 ; Beale, *How to Work &c.*, 1880 (in which every kind of apparatus is described and figured) ; and the *Journal de Micrographie* and *Zeitschrift f. Mikroskopie.*

DESCRIPTION OF PLATES.

The diameters which each object is magnified, are expressed in the Plates by small numbers placed beneath the object.

PLATE 1.—Test-Objects.

Figure

1. Hairs of the larva of the so-called *Dermestes lardarius*, viewed in balsam.
2. Hairs of the common bat (*Vespertilio pipistrellus*), in balsam. *a*, *b*, coloured hairs; *c*, a white hair.
3. Hairs of mouse (*Mus musculus*), in balsam.
4. Pits of coniferous wood, common deal (*Abies excelsa*), viewed dry.
5. Mucus- (or salivary) corpuscles, seen under different powers.
6. Scales of *Lepisma saccharina*, dry.
7. Scale from the wing of *Morpho Menelaus*, dry.
8. Scale from underside of wing of common clothes-moth (*Tinea pellionella*), dry.
9. Scales of *Hipparchia janira*. *a*, dry, and by oblique light; *b*, in balsam, by direct light; *c*, dry, after Schacht.
10. *Didymohelix ferruginea*, under different powers; *b*, with imperfect correction or adjustment, *c* with perfect correction and adjustment; *d*, separate fibres.
11. *Didymoprium Borreri*, empty cells.
12. Scales of *Podura* (*Lepidocyrtus*), under different powers, dry; *a*, 220 diameters: *c*, portion of scale—left hand, three markings as seen when the adjustment of the object-glass is correct and the markings in focus; right hand, showing the markings dividing when the adjustments are correct and the focus altered the least possible either way.
13. Pygidium of flea.
14. Frustule of *Grammatophora marina* (diagram). *a*, front view; *b*, side view.
15. Frustule of *Grammatophora subtilissima* (diagram). *a*, front view; *b*, side view.
16. *Pleurosigma angulatum*; dry valve showing the dots.
17. *Pleurosigma attenuatum*; dry valve showing the lines.
18. *Pleurosigma elongatum*; dry valve showing the lines.
19. *Bacillus subtilis*.
20. *Bacterium termo*.

TEST OBJECTS.

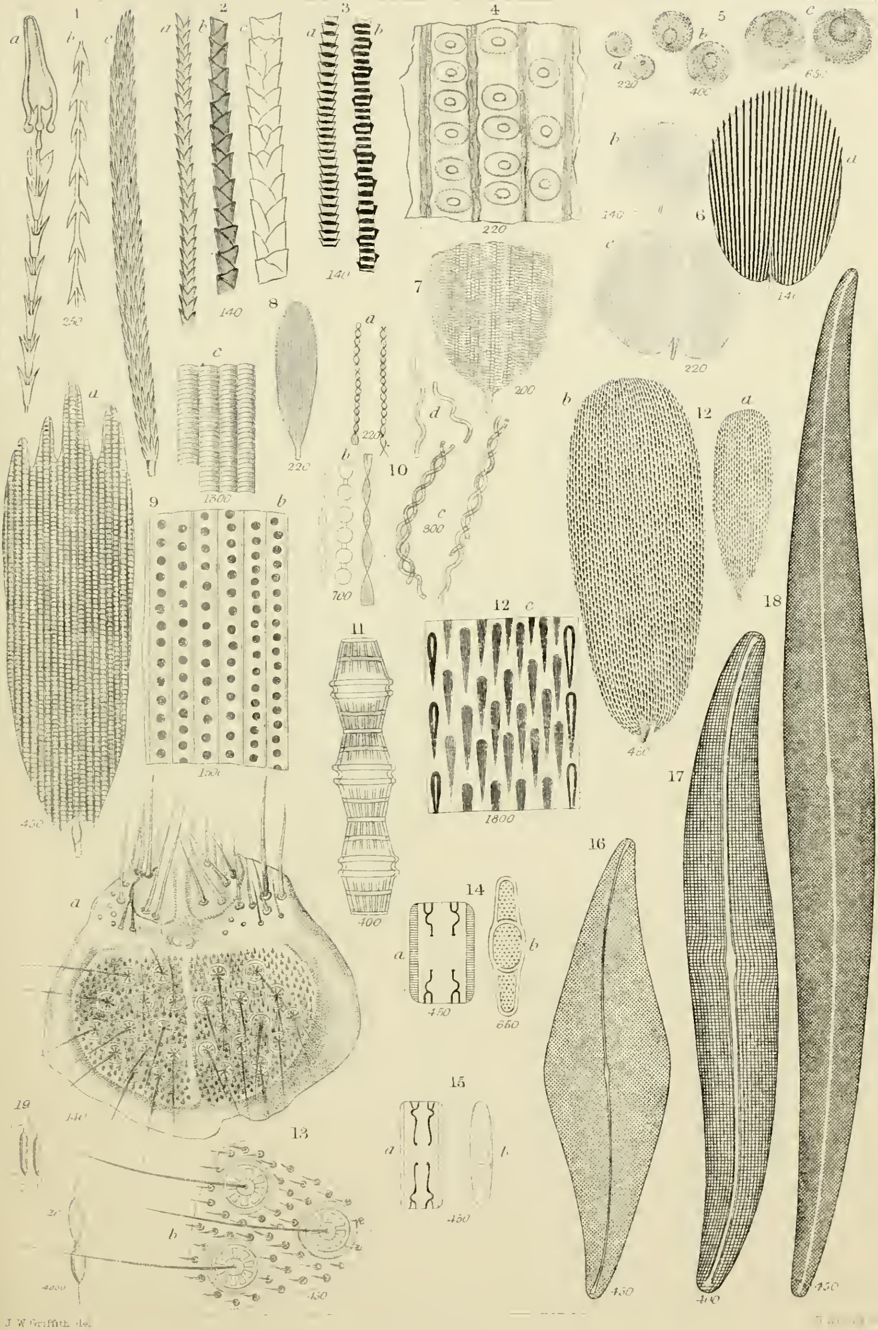

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PLATE 2.—**Adulterations.**

Figure		
1.	Tea and its adulterations.	Tea. *a*, point of leaf; *b*, under surface, with stomata and hairs; *c*, epidermis of midrib with raphides; *d*, sclerogen cell from inside the leaf.
2.		Sloe. *a*, point of leaf; *b*, upper surface, showing hairs and striated parenchyma.
3.		Elder. *a*, point of leaf; *b*, upper surface; *c*, under surface of leaf, with sinuous striated cells and glandular hairs.
4.		Cocoa. *a*, epidermis of husk; *b*, cells containing mucilage and raphides; *c*, hexagonal cells beneath the mucilage layer; *d*, parenchymatous granular cells, forming the inner layer of husk; *e*, endosperm-cells containing starch-grains.
5.	Coffee and its adulterations.	Coffee. *a*, prosenchymatous cells of investing membrane of berry; *b*, thick-walled cells of endosperm, containing oil-globules.
6.		Chicory. *a*, laticiferous vessels; *b*, pitted tissue; *c*, cellular tissue.
7.		Acorns. *a*, portion of husk; *b*, cells of endosperm filled with starch.
8.		Carob or locust-beans. *a*, *b*, characteristic tissues in pod; *c*, wedge-shaped, and *d*, sphærenchymatous cells of bean containing dark nuclei.
9.		Date-stones. Sclerogen-cells of albumen.
10.		Figs. *a*, laticiferous tissue; *b*, cellular tissue; *c*, a hair; *d*, woody tissue; *e*, sphæraphides; *f*, characteristic tissue in fig-seed.
11.		Mustard. *a*, *b*, *c*, tissues in the husk; *d*, substance of the seed consisting of granular matter and oil-globules.
12.	Pepper and its adulterations.	Pepper. *a*, *b*, *c*, characteristic tissues in the husk; *d*, cells containing starch-granules.
13.		Cayenne Pepper. *a*, very characteristic tissue; *b*, skin.
14.		Linseed. *a*, epidermis; *b*, *c*, second and third tissues; *d*, endosperm with oil-globules.
15.		Rice-husk. *a*, chief tissue of husk; *b*, the same broken up.
16.	Tobacco and its adulterations.	Tobacco. Epidermis of under surface of leaf, with glandular hairs.
17.		Dock. Epidermis of under surface of midrib, showing unicellular twisted hairs.
18.		Rhubarb. Epidermis of leaf, showing short unicellular pitted hairs.
19.		Coltsfoot. Epidermis of leaf, showing peculiar jointed hairs with long whip-like appendages.

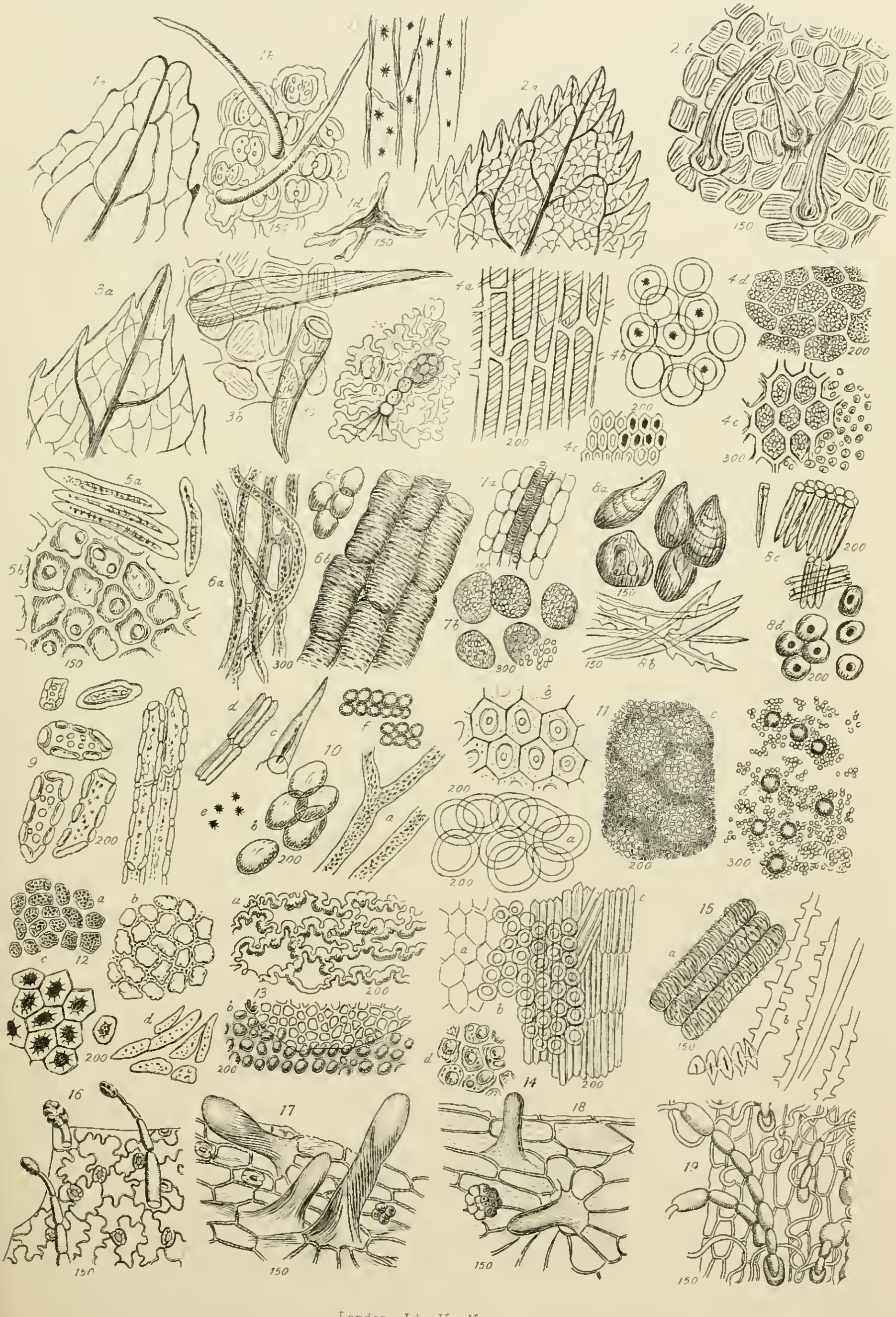

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PLATE 3.—Algæ.

Figure

1. *Agonium centrale.*
2. *Aphanocapsa virescens.*
3. *Aphanothece microscopica.*
4. *Amphithrix papillosa.*
5. *Asterothrix Pertyana.*
6. *Chamæsiphon confervicola.*
7. *Chroolepus aureum.* *b*, the zoospores escaping.
8. *Cœlastrum Naegelii.*
9. *Coniophytum Thompsoni.*
10. *Craterospermum lætevirens.*
11. *Dictyosphærium Ehrenbergii.*
12. *Microcystis progenita.*
13. *Polyedrium spinosum.*
14. *Physodictyon graniforme.*
15. *Pilinia ramosa.*
16. *Schizochlamys gelatinosa.*
17. *Schizomeris Leibleinii.*
18. *Protoderma viride.*
19. *Prasiola calophylla.*
20. *Spermosira litorea.*
21. *Sphærotilus natans.*
22. *Sorastrum spinosum.*
23. *Spondylomorum quaternarium.*
24. *Pleurocarpus mirabilis.*
25. *Stichococcus bacillaris.*
26. *Synechococcus æruginosus.*
27. *Zygogonium ericetorum.*
28. *Chætoococcus violaceus.*
29. *Palmodictyon viride.*
30. *Botryococcus Braunii.*
31. *Palmodactylon varium.*
32. *Bulbotrichia botryoides.*

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PLATE 4.—**Algæ Florideæ.**

Figure

1. *Sporochnus pedunculatus.* *a*, portion of branch; *b*, receptacle; *c*, spores and filaments.
2. *Dictyota dichotoma.* *a*, portion of frond; *b*, sorus; *c*, section of the same with spores.
3. *Polyides rotundus.* *a*, frond with warts; *b*, favellidia from wart; *c*, section of frond and wart; *d*, spore.
4. *Phyllophora rubens*; *b*, spores; *c*, a nemathecium; *d*, filaments from the same.
5. *Delesseria sanguinea*; *b*, spores; *c*, a tetraspore; *d*, capsule; *e*, branch with coccidia.
6. *Nitophyllum punctatum*; *b*, a tubercle; *c*, a tetraspore; *d*, spores.
7. *Microcladia glandulosa*; *b*, favella; *c*, tetraspore; *d*, branch with favella.
8. *Rhodymenia Palmetta*; *b*, portion with sorus; *c*, tetraspores; *d*, coccidium.
9. *Dasya arbuscula.* *a*, portion of frond; *b*, branchlet with stichidia; *c*, a ceramidium.
10. *Plocamium coccineum*; *b*, branch with tubercles; *c*, branch with sporophylls; *d*, tetraspore; *e*, spore.
11. *Rytiphlœa pinastroides*; *b*, branch with ceramidia; *c*, stichidium; *d*, ceramidium.
12. *Nemaleon multifidum.* *a*, spermatozoa adherent to trichogyne; *b*, antheridia; *c*, carpogon.
13. *Odonthalia dentata*; *b*, stichidia; *c*, ceramidia; *d*, tetraspore; *e*, spore.
14. *Sphærococcus coronopifolius*; *b*, portion with tubercles; *c*, a tubercle; *d*, spores.
15. *Bonnemaisonia asparagoides*; *b*, portion with ceramidia; *c*, ceramidium; *d*, spore.
16. *Ptilota plumosa*; *b*, *c*, favella; *d*, tetraspore.
17. *Gigartina acicularis*; *b*, *c*, tubercles with favellidia.
18. *Naccaria Wigghii* *b*, swollen ramuli with spores; *c*, filaments with spore.
19. *Bryopsis plumosa*; *b*, portion of branch magnified.
20. *Polysiphonia fastigiata*; *b*, portion magnified.
21. *Catenella opuntia.* *a*, nat. size; *b*, magnified 10 diam.; *c*, tetraspore.

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PLATE 5.—Unicellular Algæ, etc.

Figure

1. *Hydrocytium acuminatum.* *a,* young plant; *b,* more advanced; *c,* older stage, with the gonidia divided; *d,* cell about to burst; *e,* cell burst and discharging zoospores.
2. *Characium Sieboldii.* *a, b, c,* successive stages of young plant; *d,* mature cell discharging its zoospores.
3. *Sciadium arbuscula.* *a,* young plants, the right-hand one setting free the gonidia of the second generation; *b,* an older plant with an umbel of secondary cells, some discharging their gonidia of the third generation; *c,* part of an umbel of cells from the last generation of a family, the gonidia being discharged as free zoospores.
4. *Chlorosphæra Oliveri.* *a,* perfect plant; *b,* a plant dividing into two; *c,* the same with the two new cells discharged from the parent.
5. *Apiocystis Brauniana.* *a,* perfect plant; *b,* zoospore; *c,* germinating plant from a zoospore.
6. *Codiolum gregarium.* *a,* young plant; *b,* nearly mature.
7. *Chytridium Olla* upon an *Œdogonium.* *a, a,* *Chytridia* burst and discharging their zoospores; *b,* a cell not yet open.
8. *Pythium entophytum* on *Chlorosphæra.* *a,* group, partly mature; *b,* side view of a single cell perforating the cell-wall of the *Chlorosphæra,* and with its neck opened, discharging the contents.
9. *Clathrocystis æruginosa.* *a, b, c,* fronds in successive stages of growth, the natural colour; *d,* a frond dried; *e,* highly magnified fragment, showing the minute cells imbedded in the gelatinous frond.
10. *Pandorina Morum.* *a,* side view of active form with sixteen gonidia; *b,* side view of larger form with thirty-two gonidia; *c,* end view of *a*; *d,* form with crowded gonidia after fertilization, the cilia lost; *e,* the same more advanced, having lost the gelatinous common envelope, and the cell-contents red; *f,* a single encysted gonidium (resting-spore) from *e,* more magnified; *g,* side view of a gonidium with the contents becoming converted into spermatozoids; *h,* a single spermatozoid.
11. *Ophiocytium majus,* in different stages of development.
12. Spore-formation of *Vaucheria sessilis.* A, the sporange *s,* and the antheridium *a,* not yet open; B, both open, the epoch of fertilization; C, decaying filament with ripe spore.
13. Fragment of a filament of *Œdogonium tumidulum,* consisting of antheridial cells, one discharging a spermatozoid.
14. Fragment of *Œ. ciliatum,* consisting of parent cells of androspores, one of which is escaping.
15. Fragment of *Œ. gemelliparum,* male plant, consisting of antheridial cells, some bursting to discharge their twin spermatozoids.
16. Sporange with sessile dwarf male plant of *Œ. ciliatum.*
17. The same older, the dwarf male plant *a* having burst and discharged the spermatozoid which has entered the sporangial cell or oogonium.
18. Spermatozoids of *Œ. ciliatum.*
19. A dwarf male plant of *Œ. ciliatum,* discharging an androspore from its large basal cell.
20. Filament of *Œ. Braunii.* *a, a,* dwarf male plants, sessile on the filament; *b, b,* fertilized spores in the sporangial cells.
21. Ripe spore of *Œ. ciliatum.*
22. Gemmation of the resting-spore of *Bulbochæte intermedia.* *a,* ripe spore; *b,* the same enlarged; *c,* the contents dividing; *d,* the contents converted into four ciliated zoospores.

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PLATE 6.—Arachnida.

Figure

1. *Acarus* (*Tyroglyphus*) *domesticus* (cheese-mite). *a*, labium and mandibles; *b*, hair; *g*, labium; *i*, end of leg.
2. *Acarus longior.*
3. *Anystis ruricola.* *a*, palp; *b*, mandible of. (See Pl. 50. fig. 4.)
4. Epidermis of *Epeira diadema.*
5. Epidermis of a *Dermanyssus.*
6. Mandibles of *Epeira.*
7. Mandibles &c. of male *Tegenaria.* *a, b*, mandibles; *c*, palpi; *d*, maxillæ; *e*, labium.
8. End of leg of *Epeira.* *a, b*, hairs of the same.
9. Lung-plates of *Epeira*; 9 *b*, piece more magnified.
10. Spinneret of *Tegenaria domestica.* *a*, two separate spinning-tubes, the right-hand one from *Epeira*, the left-hand one from *Tegenaria.*
11. Portion of cobweb of *Epeira.*
12. Epidermis of *Arrenurus.*
13. *Arrenurus viridis*, female, dorsal view. *a*, palp; *c*, under view of male, showing round mouth with hood and first two joints of palpi, the coxæ, two stigmata and two granular plates, anal orifice and penis.
14. *Atax histrionicus.* *a*, mandible; *b*, palp; *c*, under view, with labium, coxæ, and genital plates.
15. *Hypopus muscarum.*
16. *Sarcoptes scabiei*, under view, female.
18. *Psoroptes equi*, under view.
19. *Ixodes Dugesii*, from above.
20. *Ixodes Dugesii*, anterior portion, from above. *a*, dorsal plate; *b*, basilar piece of support of rostrum; *c*, palpi, between which part of mandibles is visible.
21. *Ixodes Dugesii*, side view of palp.
22. *Ixodes Dugesii*, basilar piece from above. *a*, dotted lines indicating first joint of mandibles (*b*) seen through support; *c*, movable toothed claw.
23. *Ixodes Dugesii*, sixth and seventh joints of leg, with claws and caruncle.
24. *Dermanyssus avium*, from beneath; *a*, labium of male, compressed, with palp (*) and mandible (†); *b*, mandible of female; *c*, leg.
25. *Uropoda vegetans.* *a*, mandible; *b*, its end more magnified; *c*, sixth and seventh joint of leg in side view.
26. *Gamasus coleoptratorum*, from above. *a*, end of leg; *b*, body from beneath; *c*, mandible.
27. *Limnochares aquatica.* *a*, under view of labium and palpi; *b*, side view of labium; *c*, tarsus; *d*, scaly plate supporting eyes; *e*, two posterior coxæ of one side only; *f*, rostrum protruded, with palpi and anterior coxæ, trochanters and femora of one side only.
28. *Eylais extendens.* *a*, mouth with its hood, and first joint of palps; *b*, palp; *c*, end of mandible, with hook; *d*, under view of body, showing mouth, hood, and one palp, two groups of anterior coxæ with intervening genital orifice and two stigmata, posterior coxæ, anal orifice, and two other stigmata.
29. *Hydrachna globula.* *a*, under view, showing rostrum and palps, coxæ, heart-shaped genital plate and anus; *b*, mandible; *c*, rostrum or labium, with a palp; *d*, palp of larva; *e*, end of leg; *f*, nymphs adherent to *Nepa.*
30. *Diplodontus scapularis.* *a*, labium with palp seen from beneath; *b*, mandible.
31. *Bdella longicornis.* *b*, mandible; *a*, end, more magnified; *c*, mandible of *Bd. cærulipes.*
32. *Tetranychus glaber.* *a*, end of leg, front view, *b*, side view; *c*, palp; *d*, mandible.
33. *Megamerus celer.* *a*, labium; *b*, palp; *c*, mandible of *Megamerus roseus.*
34. *Pachygnathus velutinus.* *a*, palp; *b*, end of leg; *c*, mandible.
35. *Tetranychus cristatus*, vel *lapidum.* *a*, labium of *Raphignathus ruberrimus* with palp and mandibles *in situ*; *b*, mandible of same.
36. *Smaris papillosa*, from above. *a*, mandible.
37. *Trombidium phalangii.* *a*, palpi; *b*, mandible.
38. *Trombidium* (*Leptus*) *autumnale*, from above.
39. *Pteroptus vespertilionis*, from above.
40. *Trombidium cinereum.* *a*, labium with a palp; *b*, tarsus; *c*, plume of the labium more magnified; *d*, a mandible.
42. *Demodex folliculorum*, from beneath.
43. *Demodex folliculorum*, anterior portion from above. *a*, palps; *b*, maxillæ; *c*, labrum; *d*, tubercles.
44. *Scirus* (*Bdella*) *elaphus*, side view. *a*, end of mandible.

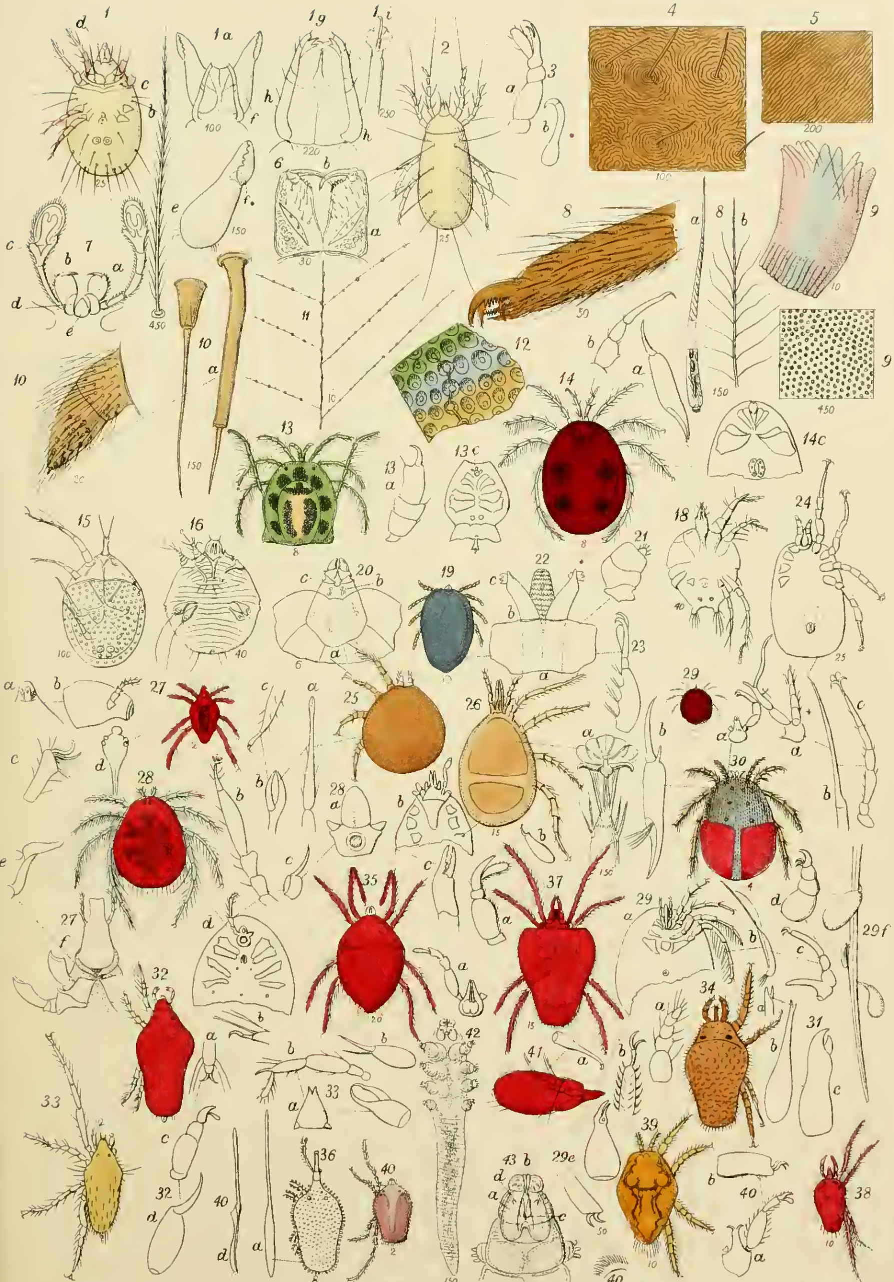

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PLATE 7.—Confervoideæ.

Figure

1. *Chlorococcum vulgare*, Grev. *a*, groups in natural condition; *b*, an isolated cell showing the granular contents; *c*, dividing cells treated with sulphuric acid and iodine.
2. *Protococcus viridis*, nob. *a*, groups of cells, the upper one with eight in a linear series; those to the right with the contents dividing into numerous gonidia (?); *b*, zoospores set free from the cells by the solution of the cellulose membrane; *c*, an isolated cell dividing and about to set free its contents as two zoospores; *d*, resting-cells with a thick coat and reddish contents; *e*, a zoospore with the cilia cast off; *f*, a zoospore with imperfect or retracted cilia; *g*, remains of a zoospore left on a glass slide for twenty-four hours.
3. *Palmella cruenta*, Br. *a*, patch of the jelly with single cells, and dividing and divided pairs; *b*, similar cells without the gelatinous layer, the smaller granules similar to those seen in the jelly of *a*; *c*, cells treated with sulphuric acid and iodine, showing the cellulose coat and granular contents; *d*, diagram indicating the relative dimensions of the cells of *Palmella nivalis*.
4. *Glœocapsa polydermatica*, Ktz.
5. *a*, *b*, *c*, *Sarcina ventriculi*, Goodsir.
6. *Coccochloris Brebissonii*, Ktz. *a*, group of cells, some dividing within their cell-coat; *b*, a linear group; *c*, a pair of cells conjugating; *d*, conjugated cells encysted and passing into the resting stage.
7. *Urococcus Hookerianus*, Berk.
8. *a*, *b*, *Hydrurus Ducluzelii*, Ag.
9. *Botrydina vulgaris*, Ktz. *a*, *b*, *c*, *d*, successive stages of growth.
10. *Tetraspora gelatinosa*, Ag. Four parent cells producing biciliated zoospores, imbedded in the gelatinous frond.
11. *Gonium pectorale*, Müll. *a*, perfect frond; *b*, the same seen edgewise; *c*, a single zoospore.
12. *Gonium tranquillum*, Ehr.
13. *Glœocapsa ampla*, Ktz.
14. *a*, *b*, *Volvox globator*?, forms related to *Syncrypta* and *Eudorina* of Ehrenberg.
15. *Spirulina oscillarioides*) Turp.?).
16. *Spirulina Jenneri*, Ktz.
17. *a*, *Bacterium termo*; *b*, *B. catenula*; *c*, *B. punctum*; *d*, *B. triloculare*; *e*, *B. lineola*; *f*, *Spirillum tenue*; *g*, *Sp. undula*.
18. *Bacillus subtilis.*
19. *Vibrio rugula.*
20. *Bacillus ulna.*

20 *a*. *Vibrio serpens.*

21. *Vibrio bacillus*, probably *Anabaina subtilissima*, Kütz.
22. *Spirochæta plicatilis.*
23. *Spirillum volutans.*

24–36. *Volvox globator*, L.

24. A perfect family.
25. With fully developed young within.
26. With yellow encysted (resting) spores.
27. Portion of the outer wall, with zoospores, some dividing.
28. Ditto, showing the cilia of the zoospores.
29. Ditto, a fragment after keeping some time in chloride of calcium, the portions around each zoospore tumid.
30. The same seen obliquely, with the cilia.
31. Spore with the protoplasm dividing.
32. Ditto, more advanced.
33. An encysted spore with undivided contents.
34. An encysted resting-spore with yellow contents, probably a subsequent stage of 33.
35. Ditto, ruptured by pressure.
36. A similar resting-spore with conical processes on the outer coat (*V. stellatus*, Ehr.).

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PLATE 8.—**Confervoideæ.**

Figure

1. *Aphanizomenon flos-aquæ*, Morr. *a*, ordinary filaments; *b*, filaments with spermatic cells; *c*, filament with a vesicular cell (*heterocyst*).

2. *Trichormus muscicola*, n. sp. *a*, filament with vesicular cell; *b*, ditto with adjoining spermatic cells; *c* and *d*, fragments treated with acid to render the membrane and contents distinct; *e* and *f*, spermatic cells similarly treated.

3. *Sphærozyga elastica*, Ag.

4. *Cylindrospermum catenatum*, Ralfs.

5. *Spermosira litorea*, Harv.

6. *Dolichospermum Ralfsii*, Thwaites.

7. *Nostoc commune*, Vauch. *a*, ordinary filaments; *b*, a single filament in its gelatinous sheath; *c* and *d*, fragments with a vesicular cell.

8. *Oscillatoria autumnalis*, Ag. *a*, fragments escaped from a sheath, *b*.

9. *Microcoleus repens*, Harv.; *b*, fragments showing the single sheaths; *c*, *d*, fragments treated with sulphuric acid and iodine.

10. *Lyngbya muralis*, Ag.

11. *Dasyglœa amorpha*, Berk.

12. *Sirosiphon ocellata*, Berk.

13. *Schizosiphon Warreniæ*, Caspary. *a*, tuft of filaments; *b*, *c*, fragments; *d*, *e*, decomposing sheaths.

14. *Tolypothrix distorta*, Kütz.

15. *Ainactis calcarea*, Kütz.; *b*, fragment showing the spiral sheath.

16. *Euactis atra*, Kütz.

17. *Schizothrix Creswellii*, Harv.

18. *Rivularia Boryana*, Kütz.

19. *Scytonema Myochrous*, Ag.

20. *Arthronema cirrhosum*, Hass.

21. *Petalonema alatum*, Berk. (*Arthrosiphon Grevillii*, Kütz.). *a*, end of a filament; *b*, cross section.

22. *Calothrix mirabilis*, Ag., *a*; *b*, junction of filaments.

CONFERVOIDEÆ.

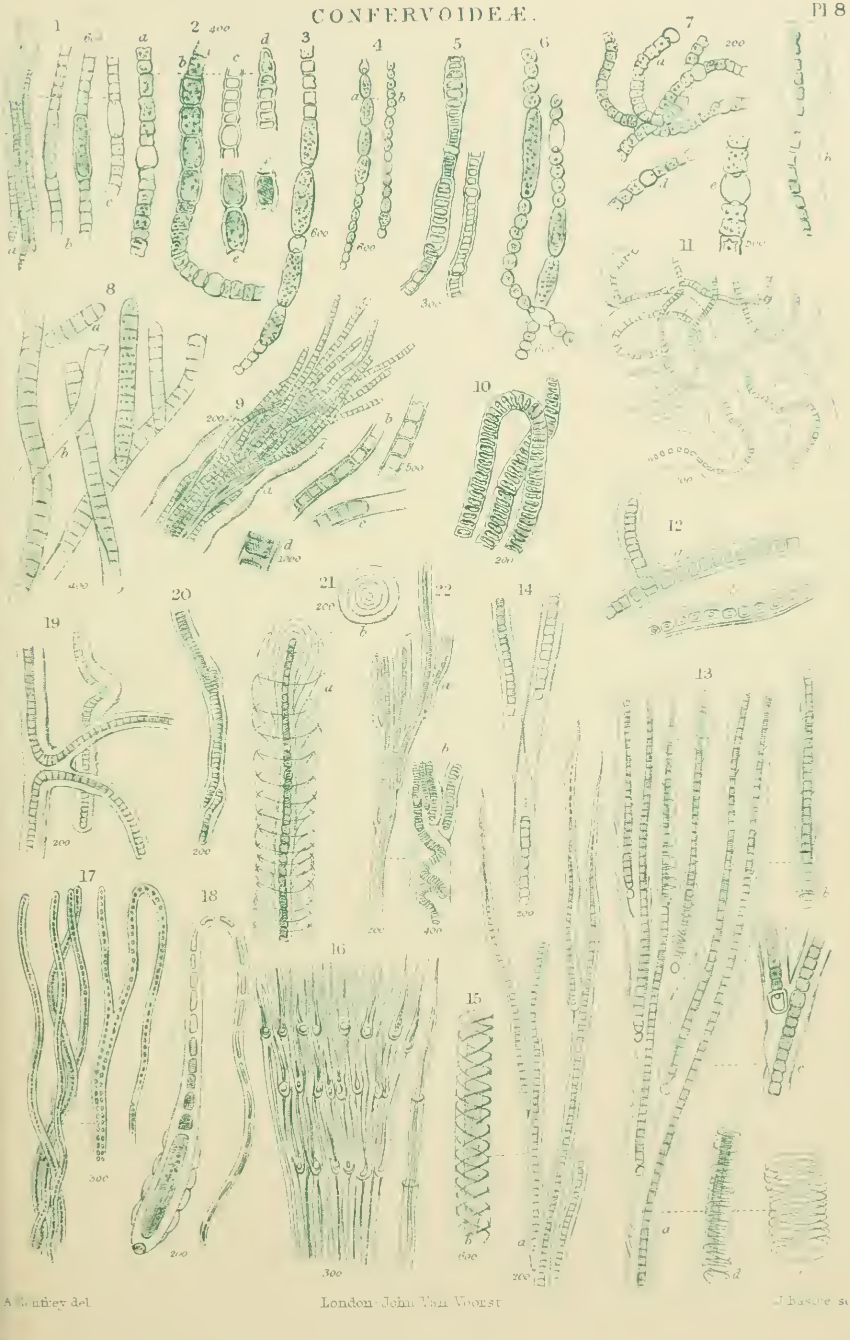

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PLATE 9.—Confervoideæ.

Figure

1. *Monostroma bullosum*, Thuret. *a*, fragment of frond, with some cells empty; *b*, ciliated zoospores from the cells; *c*, zoospore germinating.
2. *Ulva Lactuca*, L. *a*, fragment of frond; *b*, small ciliated zoospores from ditto.
3. Ditto. *a*, fragment of frond; *b*, ditto, with the cells nearly empty, showing the orifices by which the zoospores escape; *c*, large zoospore; *d*, zoospores germinating.
4. *Enteromorpha clathrata*, Grev. *a*, fragment of frond; *b*, zoospores from ditto; *c*, the same in germination.
5. *Stigeoclonium protensum*, Kütz. *a* and *b*, fragments of branched filaments, *b*, emitting zoospores, *c*, *c*; *d*, germinating zoospores.
6. *Ulothrix mucosa*, Thur. *a*, *b*, fragments of filaments; *c*, zoospores; *d*, *e*, ditto germinating.
7. *Œdogonium vesicatum*, Link. *a*, fragment of a filament; *b*, ditto, breaking up and emitting a zoospore; *c*, zoospore with a crown of cilia; *d*, *e*, germinating zoospores; *f*, membrane of a zoospore which has burst by a lid and discharged small zoospores immediately after germination; *g*, fragment of a filament with one cell containing a resting-spore; *h*, fragment of a filament in an abnormal state, containing globular bodies; *i*, germinating zoospore containing similar globular bodies.
8. *Chætophora elegans*, Ag.
9. A fragment of the same, emitting zoospores.
10. *Conferva œrea*, Dillw. *a*, fragment of filament, one cell of which has discharged its contents in the form of zoospores, *b*.
11. *Conferva floccosa*, Thur. *a*, filament breaking up; *b*, fragment of growing filament; *c*, zoospores.
12. *Rhizoclonium obtusangulum*, Kütz.
13. *Cladophora glomerata*, Kütz. *a*, filament with one fertile branch; *b*, apex of a fertile branch discharging zoospores, *c*.
14. *Sphæroplea annulina*, Kütz. *a*, growing filament; *b*, filament with the contents converted into spores.
15. *Codium tomentosum*, Ag. *a*, apex of clavate branch, with fertile cell; *b*, zoospores.
16. *Staurocarpus gracilis*, Hass.; conjugating filaments.
17. *Spirogyra quinina*, Kütz.; growing filament.
18. Conjugating filaments, with spores.
19. Ditto, with the spores germinating.
20. Half-decomposed cell, with the contents converted into almost colourless biciliated zoospores.
21. Spore formed after conjugation.
22. The same shortly before germination.
23. A similar spore, with the contents converted into globular bodies.
24. *a* and *b*, portions of a *Spirogyra*? with the contents converted into spiny globular bodies.
25. *Spirogyra quinina*, Kütz.; imperfectly conjugated cells, with the contents converted into globular bodies.
26. *Spirogyra nitida*; cell with nucleus, *n*.
27. *Spirogyra pellucida*, Kütz.; cell with nucleus, *n*, and gelatinous outer coat, *s*.
28. *Spirogyra nitida*, Kütz., half-decayed, the contents partly changed into globular masses.

PLATE 10.—Confervoideæ.—Crystals.

Figure

1. *Cosmarium margaritiferum*, Turp.; conjugating pair with imperfect sporange.
2. *Cosmarium botrytis*, Bory; conjugating pair with sporange, enveloped in jelly.

3 A. *Closterium acerosum*, Schrank. *a, b, c*, different stages of conjugation; *d*, frustules apparently produced from a sporange.

3 B. *Closterium lunula*, Müll.; the contents converted into globular bodies.

4. *Fragilaria penicillata*, Lyngb. *a* and *b*, successive stages of conjugation.

5 A. *Surirella bifrons*, Ehr.; conjugating pair, with intermediate large sporangial frustule.

5 B. *Surirella bifrons*, Ehr., with the contents converted into globular bodies.

6. *Epithemia turgida*, Ehr. *a, b, c, d, e*, successive stages of conjugation producing pairs of sporangial frustules.
7. *Melosira (Aulacosira) crenulata*, Thw. *a*, filament with two conjugating pairs of cells and perfect sporangial frustules; *b* and *c*, large filaments produced by sporangial frustules.
8. *Melosira varians*, Ag. *a*, small filament producing sporangial frustules by conjugation; *b*, large filament developed from sporangial frustules.
9. *Orthosira Dickiei*, Thw. Successive stages of production of sporangial frustules after conjugation.
10. *Pinnularia viridis*, Sm., with the contents converted into globular bodies.
11. *Pediastrum granulatum*, Ktz. *a*, a frond with most of the cells empty, three full, and the contents of another swarming out as zoospores; *b, c, d*, swarm of zoospores producing a new frond.
12. Crystals of sugar of milk.
13. ,, diabetic sugar.
14. ,, indigo, sublimed.
15. ,, oxalate of soda.
16. ,, sulphate of lime.
17. ,, phosphate of lime.
18. ,, sulphate of strontia.
19. ,, nitrate of soda.
20. ,, allantoin.
21. ,, antimoniate of soda.
22. ,, protoxide of antimony.
23. ,, butyrate of baryta. *a*, rapidly, *b*, slowly formed.
24. ,, hydrofluosilicate of baryta.
25. ,, sulphate of baryta. *a*, precipitated from concentrated, *b*, from very dilute solution.
26. ,, carbonate of potash.

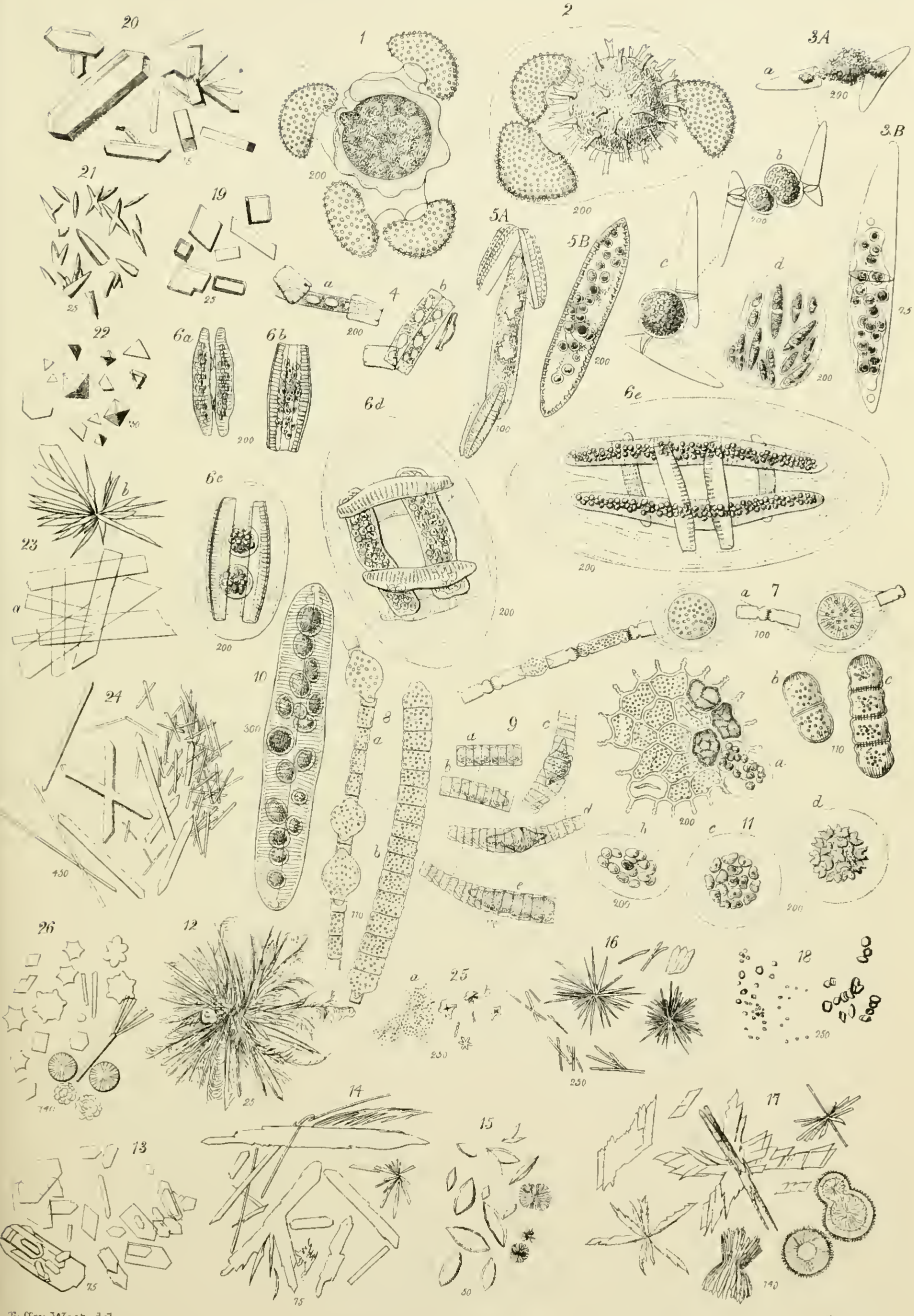

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PLATE 11.—Crystals.

Figure
1. *a*, brucia; *b*, sulphocyanide of brucia.
2. Cinchonine.
3. Sulphocyanide of cinchonine.
4. Narcotine.
5. *a*, *b*, Strychnine.
6. Sulphocyanide of strychnine.
7. Morphia.
8. Sulphocyanide of quinine.
9. Muriate of ammonia.
10. Purpurate of ammonia (murexide).
11. 12. Nitrate of potash (ANALYTIC CRYSTALS).
13. Benzoic acid. *a*, crystallized from water; *b*, sublimed.
14. Lithofellinic acid.
15. Margarine.
16. Stearic acid: *a*, margaric acid.
17. Iodo-disulphate of quinine.
18. Hippuric acid.
19. Lactate of lime.
20. Lactate of zinc.
21. Succinic acid crystallized from water.
22. Creatine.
23. Creatinine.
24. Compound of creatinine and chloride of zinc.

CRYSTALS

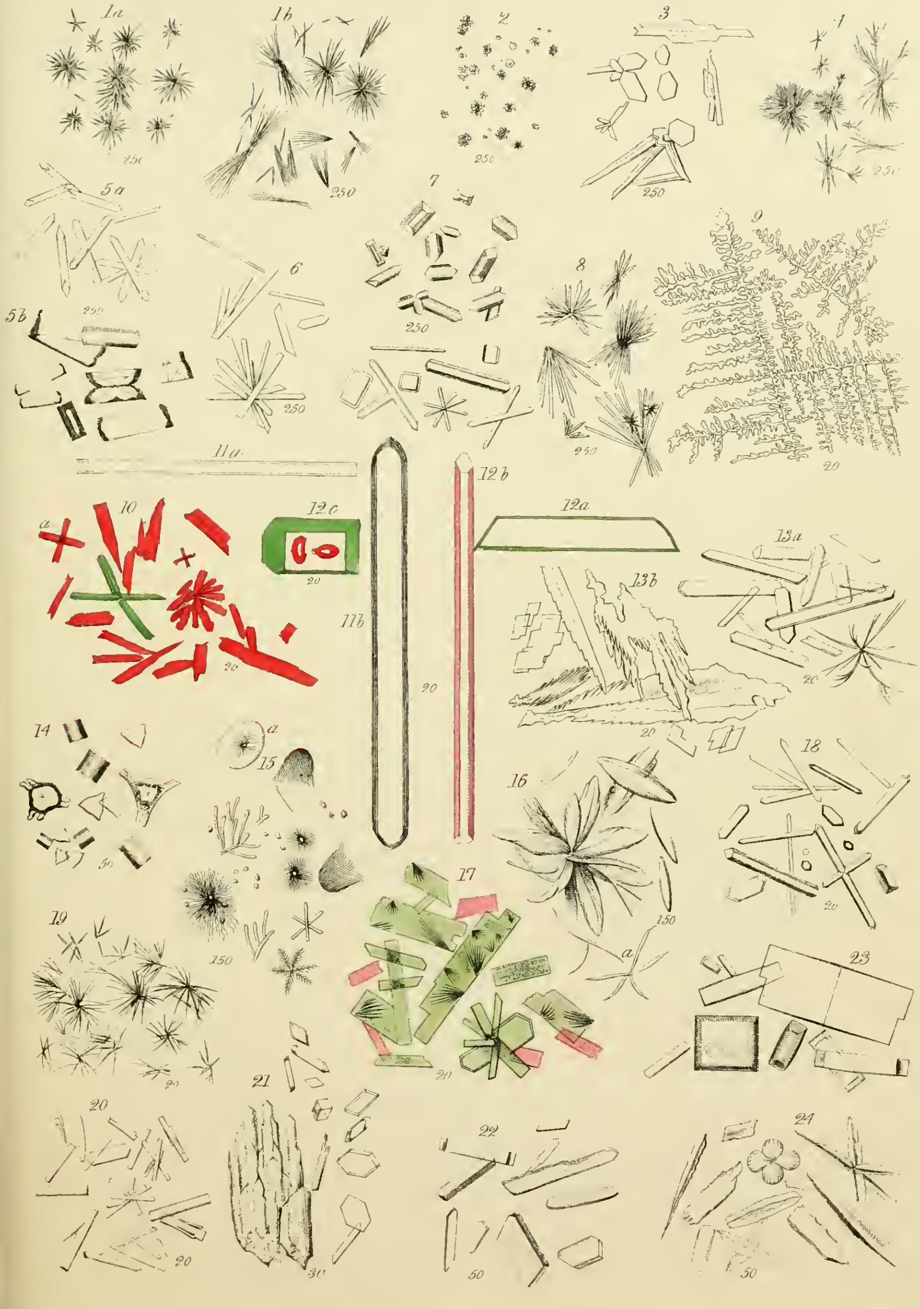

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PLATE 12.—Crystals from Animal Secretions.

Figure

1. Uric acid, human, natural. *a*, rhombs, front view; *b*, side view; *c*, *d*, striated; *e*, rhombs with obtuse angles truncated; *f*, twin crystals; *g*, ditto; *h*, hour-glass crystals; *i*, nucleated ditto; *k*, *l*, *m*, *n*, *o*, aigrettes; *p*, large dumb-bell forms.

2. Uric acid, human, natural. *a*, front, *b*, side view.

3. Uric acid, coloured artificially by murexide.

4. Uric acid, natural. *a*, front, *b*, side view; *c*, aigrette.

5. Uric acid, precipitated from solution in sulphuric acid by water.

6. Uric acid, rhombs, slightly acted upon with potash, showing spurious nuclei.

7. Uric acid, precipitated from gout-stones.

8. Uric acid of *Boa*, artificially precipitated. *a*—*d*, from solution in sulphuric acid by water; *e*—*h*, from solution in potash by muriatic acid.

9. Uric acid, precipitated from the excrement of the tortoise.

10. Uric acid, precipitated:—*a*, from the excrement of the clothes-moth; *b*, from stag-beetle (*Lucanus cervus*).

11. Urate of soda and ammonia. *a*, spheres with nuclei and concentric rings, artificial; *b*, surface covered with radiating needles; *c*, *d*, *e*, natural forms; *f*, *g*, artificial.

12. Urates of soda and ammonia. *a*, artificial urate of ammonia, deposited on cooling of an aqueous solution; *b*, natural urate of soda, as composing the chalky matter around gouty joints.

13. *a*, *b*, Urate of lime.

14. *a*, *b*, Urate of magnesia.

15. Uric acid, precipitated by an acid from human urine.

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PLATE 13.—Crystals from Animal Secretions.

Figure

1. Various prismatic forms of the ammonio-phosphate of magnesia (triple phosphate), naturally formed in human secretions.
2. Feathery or penniform crystals of the same salt.
3. Stellate form of the same salt.
4. Minute imperfectly formed prisms of the same.
5. Cystic oxide.
6. Carbonate of lime deposited from water by standing.
7. Carbonate of lime from the urine of the horse, natural.
8. Carbonate of lime from the urine of man, natural.
9. Octahedra of oxalate of lime, as seen in water.
10. Octahedra of oxalate of lime, as seen when dried.
11. Ellipsoidal forms of oxalate of lime, natural.
12. Ellipsoidal constricted, or dumb-bell forms of the same, natural.
13. Crystals of oxalate of lime, prepared with acid.
14. Modified octahedra of the same salt, formed by double decomposition.
15. Crystals of bilifulvine, natural, human.
16. Crystals of hæmatoidine.
17. Crystals of urea.
18. Nitrate of urea; *a*, *b*, slowly, *c*, rapidly formed.
19. Oxalate of urea.
20. Uroglaucine.
21. Cholesterine.

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PLATE 14.—Desmidiaceæ.

Figure

1. *Hyalotheca dissiliens,* front view.
2. *Hyalotheca dissiliens,* side or end view.
3. }
4. } *Hyalotheca dissiliens,* conjugating cells, with sporangia.
5. *Didymoprium Grevillii,* front view.
6. *Didymoprium Grevillii,* side view.
7. *Desmidium Swartzii,* front view.
8. *Desmidium Swartzii,* side view.
9. *Sphærozosma vertebratum,* front view.
10. *Sphærozosma vertebratum,* side view.
11. *Micrasterias denticulata,* cell dividing.
12. *Micrasterias denticulata,* sporangium.
13. *Micrasterias rotata.*
14. *Euastrum verrucosum.*
15. *Euastrum oblongum.*
16. *Euastrum didelta.*
17. *Euastrum didelta,* cell free from contents.
18. *Cosmarium pyramidatum.*
19. *Cosmarium pyramidatum,* empty cell.
20. *Cosmarium crenatum.*
21. *Cosmarium margaritiferum.*
22. *Cosmarium tetraophthalmum.*
23. *Xanthidium armatum.*
24. *Xanthidium armatum,* empty cell.
25. *Xanthidium fasciculatum.*
26. *Staurastrum dejectum.*
27. *Arthrodesmus convergens.*
28. *Staurastrum margaritaceum,* front view.
29. *Staurastrum margaritaceum,* side view.
30. *Staurastrum gracile,* front view.
31. *Staurastrum gracile,* side view.
32. *Didymocladon furcigerus,* front view; fig. 56, end view.
33. *Tetmemorus granulatus.*
34. *Tetmemorus granulatus,* empty cell.
35. *Tetmemorus lævis,* in conjugation.
36. *Penium Brebissonii.*
37. *Penium margaritaceum,* empty cell.
38. *Docidium truncatum.*
39. *Docidium baculum.*
40. *Closterium lunula.*
41. *Closterium acerosum.*
42. *Closterium acerosum,* in conjugation.
43. *Closterium moniliferum.*
44. *Closterium didymotocum.*
45. *Closterium setaceum.*
46. *Closterium setaceum,* in conjugation.
47. *Ankistrodesmus falcatus.*
48. *Pediastrum Boryanum.*
49. *Pediastrum granulatum,* empty cell.
50. *Scenedesmus quadricauda.*
51. *Scenedesmus obliquus.*
52. *Aptogonum desmidium,* side view; fig. 55, front view.
53. *Scenedesmus obtusus,* just after division.
24\. *Scenedesmus obtusus,* ordinary state.
55\. *Aptogonum desmidium,* front view; fig. 52, side view.
56\. *Didymocladon furcigerus*; *a*, end view; fig. 32, front view.
57\. *Closterium Griffithii.*
58\. " "
59\. *Spirotænia condensata.*

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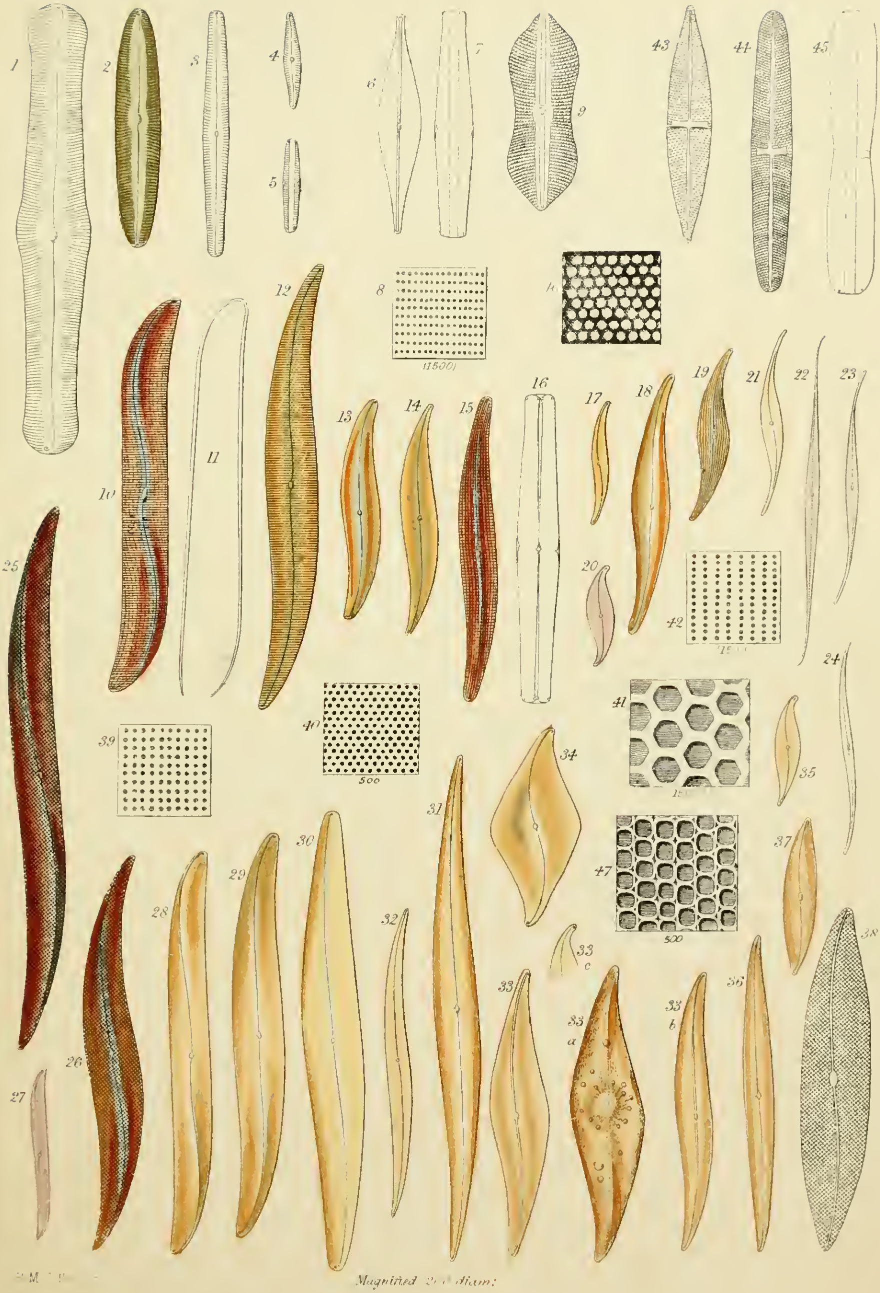
PLATE 15.—Diatomaceæ.

The figures represent the prepared frustules or valves, except when otherwise stated.

Figure
1. *Pinnularia nobilis*, side view.
2. *Pinnularia viridis*, side view, with endochrome.
3. *Pinnularia oblonga*, side view.
4. *Pinnularia radiosa*, side view.
5. *Pinnularia radiosa*, front view.
6. *Navicula cuspidata*, side view.
7. *Navicula cuspidata*, front view.
8. Portion of the valve of a *Navicula*, showing the transverse rows of dots.
9. *Navicula didyma*, side view.
10. *Pleurosigma balticum*, side view.
11. Hoop of the same, side view.
12. *Pleurosigma strigilis*, side view.
13. *Pleurosigma hippocampus*, side view.
14. *Pleurosigma acuminatum*, side view.
15. *Pleurosigma attenuatum*, side view.
16. *Pleurosigma attenuatum*, front view.
17. *Pleurosigma Spencerii*, side view.
18. *Pleurosigma lacustre*, side view.
19. *Pleurosigma littorale*, side view.
20. *Pleurosigma distortum*, side view.
21. *Pleurosigma fasciola*, side view.
22. *Pleurosigma macrum*, side view.
23. *Pleurosigma prolongatum*, side view.
24. *Pleurosigma tenuissimum*, side view.
25. *Pleurosigma formosum*, side view.
26. *Pleurosigma decorum*, side view.
27. *Pleurosigma obscurum*, side view.
28. *Pleurosigma speciosum*, side view.
29. *Pleurosigma strigosum*, side view.
30. *Pleurosigma rigidum*, side view.
31. *Pleurosigma elongatum*, side view.
32. *Pleurosigma delicatulum*, side view.
33. *Pleurosigma angulatum*, side view. *a*, with endochrome; *b*, variety β; *c*, variety γ, end of.
34. *Pleurosigma quadratum*.
35. *Pleurosigma æstuarii*.
36. *Pleurosigma intermedium*.
37. *Pleurosigma transversale*.
38. *Pleurosigma transversale*.
39. Portion of valve of *P. balticum*.
40. Portion of valve of *P. strigosum*.
41. Portion of valve of *P. angulatum* (Diatomaceæ).
42. Portion of valve of *P. littorale*.
43. *Stauroneis phœnicenteron*, side view.
44. *Stauroneis pulchella*, side view.
45. *Stauroneis pulchella*, front view.
46. *Pleurosigma angulatum*, showing the dots as pearls.
47. *Isthmia enervis*, portion of.



Magnified 2.. diam:

PLATE 16.—Diatomaceæ.

Figure
1. *Achnanthes longipes*; the front view of the frustules is visible.
2. *Achnanthes longipes,* side view, upper valve.
3. *Achnanthes longipes,* side view, lower valve.
4. *Achnanthes exilis.*
5. *Achnanthidium microcephalum,* side and front views.
6. *Achnanthidium flexellum*, front and side views.
7. *Amphipleura pellucida.* *a*, side view of frustule; *b*, single valve; *c*, *Amphipleura sigmoidea.*
8. *Amphiprora alata.* *a*, side view; *b*, front view.
9. *Amphitetras antediluviana.* *a*, frustules united; *b*, side view; *c*, front view; *d*, perspective view.
10. *Amphora ovalis*, front view; 10 *a*, transverse section.
11. *Amphora membranacea*, front view of single valve.
12. *Arachnoidiscus Ehrenbergii*, side view.
13. *Arachnoidiscus Ehrenbergii*, portion of valve from the centre to the circumference.
14. *Bacillaria paradoxa.* *a*, front view of conjoined frustules; *b*, side view; *c*, front view of single frustule. See also Pl. 18. fig. 17.
15. *Biddulphia pulchella*, front view. *a*, frustule dividing, front view.
16. *Campylodiscus costatus*, side view. *b*, front view.
17. *Cocconeis pediculus.*
18. *Cocconeis scutellum,* single valve (side view).
19. *Cocconema lanceolatum.*
20. *Cocconema lanceolatum*, single valve (side view).
21. *Cyclotella operculata.* *a*, side view; *b*, front view.
22. *Cyclotella Kutzingiana*, front view.
23. *Cymatopleura solea.* *a*, side view; *b*, front view.
24. *Cymatopleura elliptica,* side view.
25. *Denticula obtusa.* *b*, front view; *c*, side view of single frustule; *d*, front view of the same.
26. *Diatoma vulgare*, connected frustules. *a*, side view; *b*, front view of single frustule.
27. *Diadesmis confervacea.* *a*, front view; *b*, side view.
28. *Meridion constrictum.* *a*, connected frustules forming a coil; *b*, front view of single frustule.
29. *Doryphora amphiceros.* *a*, side view of frustule with endochrome; *b*, front view; *c*, prepared single valve.
30. *Eupodiscus argus.* *a*, side view; *b*, front view; *c*, fragment, more highly magnified.
31. *Eupodiscus sculptus*, side view.
32. *Epithemia turgida.* *a*, side view; *b*, front view.
33. *Fragilaria capucina*; side view of frustule, front view of the same, and frustules united into a filament.
34. *Gomphonema acuminatum.* *a*, filiform stipes; *b*, side view, *c*, front view of frustule.
35. *Grammatophora marina,* connected frustules. *b*, single frustule, front view; *c*, side view.
36. *Himantidium pectinale,* united frustules, front view. *a*, side view of single frustule; *b*, side view of variety β; *c*, sporangial frustule.

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PLATE 17.—Diatomaceæ.

Figure

1. *Hyalosira rectangula*, front view of connected frustules.
2. *Isthmia enervis*, front view.
3. *Licmophora splendida.* *b*, side view; *c*, front view of single frustule.
4. *Lithodesmium undulatum.* *a*, front view; *b*, side view.
5. *Melosira nummuloides*, front view.
6. *Melosira varians*, front view. *a*, side view.
7. *Meridion circulare.* *a*, frustules united into a coil, front view; *b*, side view of single frustule.
8. *Micromega parasiticum*, natural size. *b*, portion of a filament containing the frustules; *c*, side view, *d*, front view of a frustule.
9. *Nitzschia sigmoidea.* *a*, side view; *b*, front view.
10. *Nitzschia lanceolata.* *a*, front view; *b*, separate valve; *c*, side view of frustule; 10 *d*, portion of valve, showing the dots.
11. *Nitzschia longissima.* *a*, side view; *b*, front view.
12. *Nitzschia reversa*, front view of single valve.
13. *Nitzschia.* *a*, *tænia*; *b*, *acicularis.*
14. *Odontidium turgidulum.* *a*, frustules united, front view; *b*, single valve, side view.
15. *Orthosira Dickieii.* *a*, front view; *b*, side view.
16. *Podoliscus jamaicensis.* *a*, side view; *b*, front view.
17. *Podosphenia Ehrenbergii.* *a*, front view; *b*, side view of single frustule.
18. *Rhabdonema arcuatum.* *a*, united frustules, front view; *b*, side view of single frustule. See also Pl. 18. fig. 69.
19. *Rhipidophora paradoxa.* *b*, front view of single frustule; *c*, side view of the same.
20. *Striatella unipunctata.* *a*, front view; *b*, the same; *c*, side view.
21. *Surirella gemma.* *a*, side view; *b*, front view.
22. *Surirella bifrons.* *a*, front view; *b*, side view.
23. *Synedra radians.* *a*, attached frustules; *b*, side view of prepared frustule; *c*, front view of the same.
24. *Synedra fulgens.* *a*, side view; *b*, front view of a prepared frustule.
25. *Synedra capitata*, side view.
26. *Sphenosira catena.* *a*, united frustules, front view; *b*, side view of single frustule.
27. *Tabellaria flocculosa.* *a*, united frustules, front view; *b*, side view of single frustule.
28. *Tetracyclus lacustris*, united frustules, front view; *a*, side view.
29. *Triceratium favus.* *a*, side view; *b*, front view.
30. *Tryblionella scutellum*, side view.
31. *Tryblionella gracilis*, front view.
32. *Tryblionella gracilis*, diagram of transverse section.

DIATOMACEÆ.

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PLATE 18.—Diatomaceæ, etc.

Figure
1. *Actiniscus tetrasterias.*
2. *Actiniscus pentasterias.*
3. *Actiniscus quinarius.*
4. *Actiniscus discus.*
5. *Actiniscus rota.*
7. *Anaulus scalaris.*
8. *Actinogonium septenarium.*
9. *Arthrodesmus minutus.*
10. *Amaroucium proliferum*: *a*, nat. size; *b*, individual body magnified (TUNICATA).
11. *Amphicampa eruca.*
12. *Amphicampa mirabilis.*
13. *Asellus vulgaris.*
14. *Asterionella formosa.*
15. *Asteromphalos Beaumontii.*
16. *Biddulphia rhombus.*
17. *Bacillaria paradoxa* (compare Pl. 16. fig. 14).
18. *Bacteriastrum curvatum.*
19. *Bowerbankia imbricata*: *a*, nat. size; *b*, portion magnified; *c*, single body.
20. *Botryllus polycyclus*: *a*, nat. size; *b*, separate body (TUNICATA).
21. *Coscinodiscus* (*Craspedodiscus*) *pyxidicula.*
22. *Gammarus pulex.*
23. *Mastogonia*: *a*, *crux*; *b*, *actinoptychus.*
24. *Mastogonia prætexta.*
25. *Mastogonia hexagona.*
26. *Stephanodiscus Niagaræ.*
27. *Stephanodiscus lineatus.*
28. *Stephanodiscus sinensis.*
29. *Stephanodiscus Ægyptiacus.*

29*. *Stephanodiscus Bramaputræ.*

30. *Stephanogonia polygona.*
31. *Hercotheca mammillaris.*
32. *Syringidium bicorne.*
33. *Syringidium palæmon.*

Figure

34. *Biblarium castellum.*
35. *Biblarium compressum.*
36. *Biblarium compressum.*
37. *Biblarium elegans.*
38. *Biblarium ellipticum.*
39. *Biblarium emarginatum.*
40. *Biblarium emarginatum.*
41. *Biblarium strumosum.*
42. *Biblarium stella.*
43. *Biblarium speciosum.*
44. *Biblarium rhombus.*
45. *Biblarium lineare.*
46. *Biblarium lancea.*
47. *Biblarium glans.*
48. *Biblarium follis.*
49. *Stylobiblium clypeus.*
50. *Stylobiblium*: *a*, *b*, *clypeus*; *c*, *divisum*; *d*, *eccentricum.*
51. *Halionyx undenarius.*
52. *Odontodiscus eccentricus.*
53. *Omphalopelta areolata.*
54. *Symbolophora acuta.*
55. *Symbolophora micrasterias.*
56. *Symbolophora pentas.*
57. *Systephania corona.*
58. *Systephania diadema.*
59. *Syndendrium diadema.*
60. *Auliscus pruinosus.*
61. *Dicladia antennata.*
62. *Dicladia bulbosa.*
63. *Dicladia capreolus.*
64. *Dicladia capreolus.*
65. *Dicladia clathrata.*
66. *Periptera tetracladia.*
67. *Periptera capra.*
68. *Dictyolampra stella.*
69. *Rhabdonema arcuatum*; compound frustule.

FOSSIL DIATOMACEÆ, &c. Pl 18.

Magnified 250–300 diameters, unless otherwise expressed

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PLATE 19.—**Diatomaceæ and Entomostraca.**

Figure

1. *Acroperus nanus.*
2. *Acroperus harpæ.*
3. *Alteutha depressa.* *a*, first pair of legs.
4. *Alona reticulata.*
5. *Alona quadrangularis.*
6. *Anomalocera Patersonii*, male.
7. *Anchorella uncinata.* *a*, arms; *b*, abdomen; *c*, ovarian tubes.
8. *Berkeleya fragilis.* *a*, natural size; *b*, portion of a branch containing frustules; *c*, side view, *d*, front view of a single frustule.
9. *Biddulpha aurita.* Frustules undergoing division: *a*, hoop of original frustule, to which two new halves (*c*) have been formed; the hoop of the new frustules is seen at *b*; the hoop of the parent has separated from the two frustules *d d*, which are perfectly formed, each with its new hoop.
10. *Encyonema prostratum.* *a*, frustules contained in a gelatinous tube, side view; *b*, front view; *c*, separate frustules, side view.
11. *Rhaphidoglœa micans.* *a*, natural size; *b*, group of frustules; *c*, single frustule, front view.
12. *Schizonema Dillwynnii.* *a*, natural size; *b*, filaments containing frustules; *c*, front view, *d*, side view of frustule.
13. *Zygoceros rhombus.* *a*, front view; *b*, side view.
14. *Syncyclia salpa*; frustules immersed in a gelatinous mass.
15. *Homœocladia anglica.* *a*, portion of the natural size; *b*, part of a filament containing two frustules; *c*, front view, *d*, side view of a prepared frustule.
16. *Dickieia alvoides.* *a*, natural size; *b*, portion of frond containing frustules; *c*, *d*, *f*, prepared frustules, front view; *e*, side view.
17. *Frustulia saxonica*; frustules immersed in a gelatinous mass.
18. *Cymbosira Agardhii.* *a*, united frustules; *b*, front view, *c*, side view of prepared frustules.
19. *Sphenella vulgaris.* *a*, front view; *b*, side view.
20. Spermatozoa of a *Cypris.*
21. *Cetochilus septentrionalis*, dorsal view.
22. *Notodelphys ascidicola*, female.
23. *Lepeophthirus pectoralis*, female.
24. *Lerneonema spratta*, female.
25. *Macrothrix laticornis*, female.
26. *Moina rectirostris*, female.
27. *Sida crystallina.*
28. *Nebalia bipes.*
29. *Polyphemus pediculus.*
30. *Evadne Nordmanni.*
31. *Peracantha truncata.* *a*, superior antenna.
32. *Pleuroxus trigonellus.*
33. *Terpsinoe musica*: front view, Pl. 25. fig. 10.
34. *Podosira hormoides*, front view.
35. *Tessella interrupta*, front view.
36. *Nicothoe astaci.* *a*, ovaries.
37. *Cythere lutea.* Poison-gland, *a*, and urticating organ, *b*.

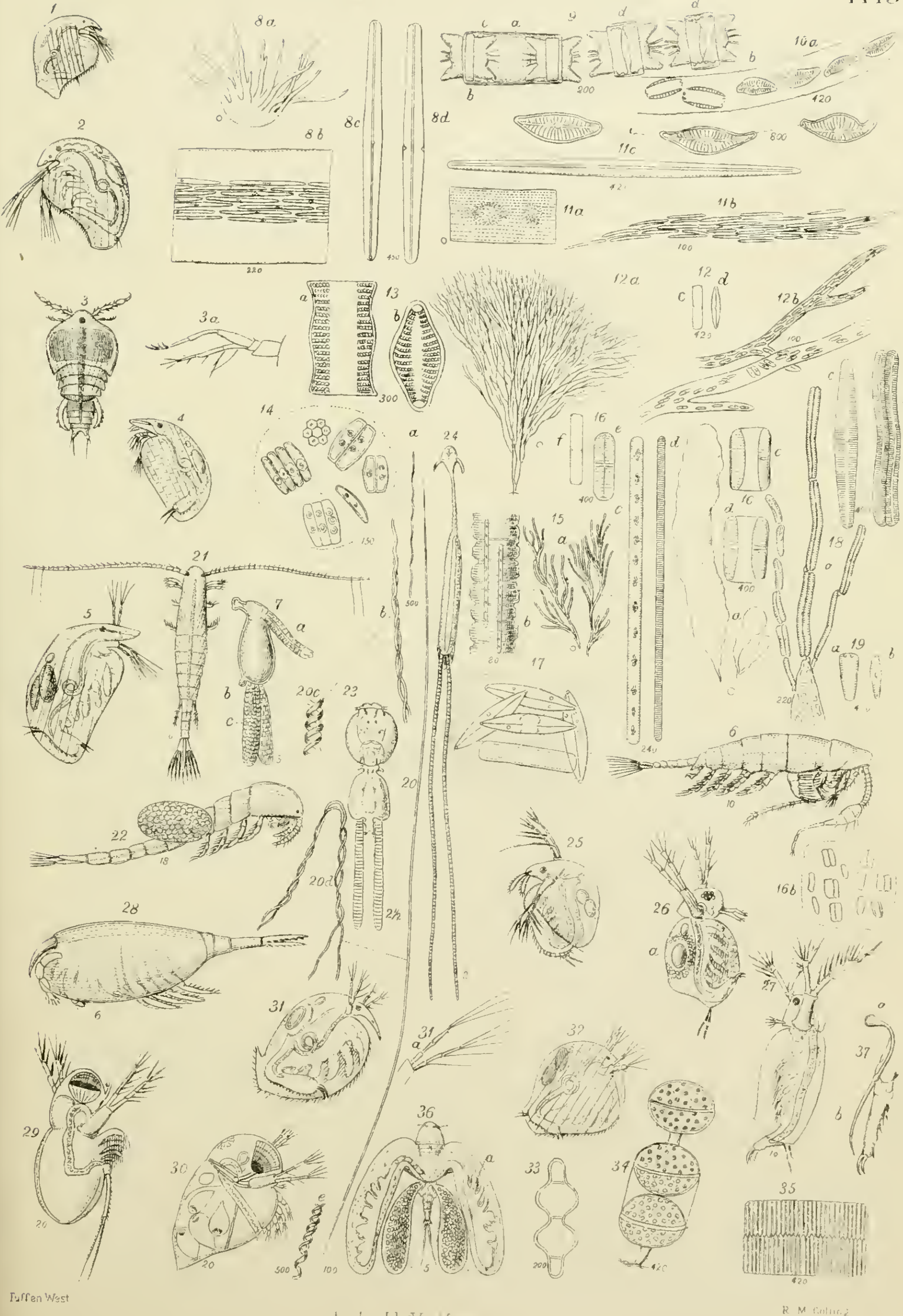

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PLATE 20.—Entomostraca.

Figure

1. *Argulus foliaceus*, seen from beneath. *a*, anterior, *b*, posterior antennæ; *c*, rostrum; *d*, suckers, representing the first pair of legs; *e*, second pair of legs; *f*, four posterior pairs of legs.
2. *Bosmina longirostris*; 2*, the same, natural size.
3. *Branchipus stagnalis.*
4. *Camptocercus macrourus.*
5. *Cypris reptans*; 5 *a*, inferior antenna.
6. *Canthocamptus minutus*; 6*a*, inferior antenna; 6*b*, first pair of foot-jaws 6*c*, second pair of foot-jaws.
7. *Chydorus sphæricus.*
8. *Cyclops quadricornis*, male. *a*, *b*, superior antennæ
9. *Cyclops quadricornis*, female. *a*, superior, *b*, inferior antennæ.
10. *Cyclops quadricornis*, inferior antenna.
11. *Cyclops quadricornis*, mandible; *a*, body; *b*, serrated seta; *c*, filaments of palp.
12. *Cyclops quadricornis*, first pair of foot-jaws.
13. *Cyclops quadricornis*, second pair of foot-jaws: 13*a*, internal portion; 13 *b*, external portion.
14. *Cyclops quadricornis*, first pair of thoracic legs.
15. *Cyclops quadricornis*, fifth pair of legs.
16. *Cyclops quadricornis*, recently hatched.
17. *Cypris tristriata.*
18. *Cypris tristriata*, superior antenna.
19. *Cypris tristriata*, inferior antenna.
20. *Cypris tristriata*, mandible.
21. *Cypris tristriata*, first pair of jaws; *a*, basal plate; *b*, branchial lamina.
22. *Cypris tristriata*, second pair of legs.
23. *Cypris tristriata*, first pair of legs.
24. *Cypris tristriata*, second pair of legs.
25. *Cypris tristriata*, lateral half of the abdomen.
26. *Cythere inopinata.*
27. *Daphnella Wingii.*
28. *Daphnia pulex.* *a*, superior antennæ; *b*, inferior antennæ; *c*, heart.
29. *Daphnia pulex*, first pair of legs.
30. *Daphnia pulex*, second pair of legs.
31. *Daphnia pulex*, third pair of legs.
32. *Daphnia pulex*, fourth pair of legs.
33. *Daphnia pulex*, fifth pair of legs.
34. *Daphnia pulex*, mandible.
35. *Daphnia pulex*, labrum.
36. *Daphnia pulex*, jaw.
37. *Daphnia reticulata.* *a*, ephippium.
38. *Diaptomus castor.*
39. *Eurycercus lamellatus.*

PLATE 21.—Entozoa.

Figure

1. *Echinococcus veterinorum* (*hominis*) ; 1 *a*, in the contracted state ; 1 *b*, hooks ; 1 *c*, *d*, *f*, in the expanded state ; 1 *e*, imperfectly developed individual.
2. *Echinococcus veterinorum* (*hominis*), cyst reproducing by external gemmation.
3. *Cysticercus cellulosæ*, *a*, nat. size ; 3 *b*, *C. fasciolaris*, head of.
4. *Anguillula fluviatilis.*
5. *Anguillula aceti.*
6. *Anguillula tritici.* *a*, *b*, ova ; *c*, mature individual ; *d*, imperfectly developed individual.

6 *e*. *Dochmius* (*Anchylostomum*) *duodenalis*, male ; *, head of female ; +, male, †, female, nat. size.

7. *Gyrodactylus auriculatus*, 8 diameters.
8. *Ascaris vermicularis* ; 8 *a*, head ; *d*, stomach ; *e*, œsophagus; *g*, anus; *h*, ovaries ; *k*, oviduct.
9. *Ascaris lumbricoides*; *a*, front view of head ; 9 *b*, tail of male, with spicula ; 9 *c*, side view of head.
10. *Cœnurus cerebralis*, portion of a cyst,
12. *Tœnia solium*, head of, side view ; two of the suckers only are visible.
13. *Tœnia solium*, head of, front view ; all the four suckers are visible.
14. *Tœnia solium*, a single joint, injected. *a*, gastric (?) canals ; *b*, vascular canals ; *c*, testicular capsule ; *d*, spermatic duct ; *e*, oviduct ; the dark ramified organ is the ovary.
15. *Tœnia solium*, ovum of.
16. *Trichina spiralis*, lying within its cyst, imbedded in muscle.
17. *Trichina spiralis*, removed from its cyst.
18. *Trichina spiralis*, internal organs.
19. *Trichocephalus dispar*, male.
20. *Trichocephalus dispar*, portion of the neck.
21. *Trichocephalus dispar*, female ; 21 *a*, ovum.
22. *Monostoma verrucosum*, ovum of.
23. *Tœnia variabilis*, ovum of.
25. *Gregarina sipunculi.*
26. *Gregarina sipunculi*, with two enclosed cells.
27. Caudate pseudo-navicula, from the abdominal cavity of *Sipunculus nudus.*
28. *Gregarina Sieboldii.*
29. Young pseudo-navicula cyst of *Gregarina sœnuridis*, from testis of *Sœnuris variegata*, consisting of loosely connected ovate cells, without an outer envelope.
30. The same, with an outer envelope.
31. More advanced pseudo-navicula cyst of the same *Gregarina*, with two cells containing rounded pseudo-naviculæ.
32. The same, with elongated pseudo-naviculæ ; the cyst has three cell-like bodies on its surface.
33. The same with a single cavity, containing elongated pseudo-naviculæ.
34. Two *Gregarinæ sœnuridis*, adherent by their ends.
35. *Echinorhynchus anthuris*, head, 25 diameters.

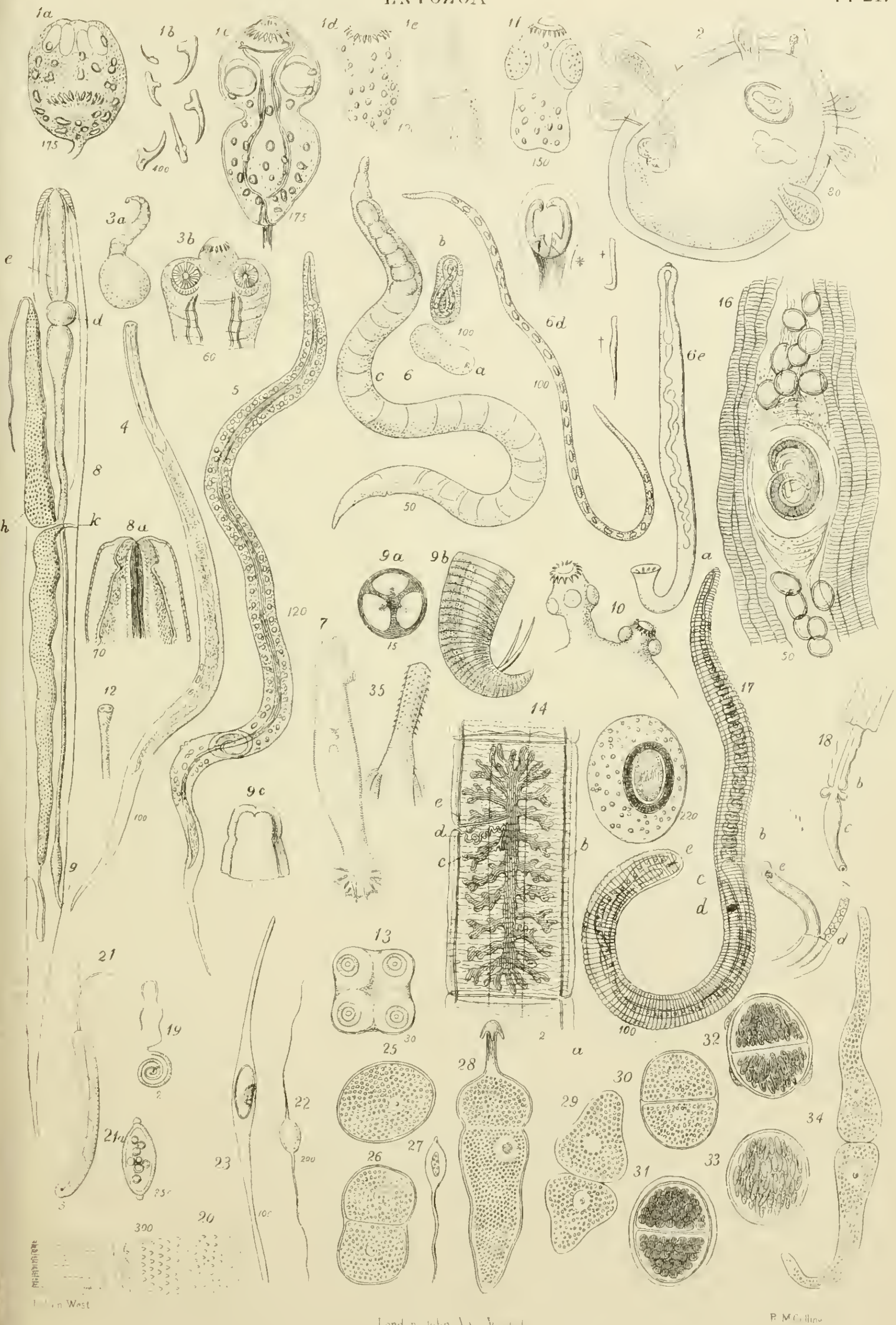

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PLATE 22.—Fish-scales, etc.

Figure

1. Scale of sturgeon, perpendicular section. *a*, outer spongy portion; *b*, inner laminated portion; 1 *c*, transverse section of outer portion.
2. Skin of thornback skate (*Raia clavata*), viewed from above.
3. Large spine of skate, side view.
4. Portion of transverse section of large spine of skate (fig. 3 *b*).
5. Longitudinal section of tooth of a small spine of skate (fig. 2).
6. Scale of perch (*Perca fluviatilis*).
7. Perch-scale, portion of (fig. 6 *a*), more magnified.
8. Perch-scale, portion of (fig. 6 *b*), more magnified.
9. Scale of sole (*Solea vulgaris*).
10. Scale of roach (*Leuciscus rutilus*).
11. Scale of roach (*Leuciscus rutilus*), portion of surface more highly magnified.
12. Scale of roach (*Leuciscus rutilus*), perpendicular section.
13. Scale of minnow (*Leuciscus phoxinus*).
14. Feather of finch; shaft with medullary cells.
15. Feather of goose (*Anser cinereus*). *a*, pinnæ with hooks; *b*, pinnæ with teeth; *c*, barbs.
16. Separate pinnæ. *a*, with hooks; *b*, with teeth.

17., 18. Feather (downy), free barbs of.

19. Skin of eel (*Anguilla vulgaris*), with stellate pigment-cells, and indications of subjacent scales.
20. Scale of eel (*Anguilla vulgaris*). 20 *a*, portion, more magnified.
21. Calcareous corpuscles from the same, left after red heat.
22. Scale of jack or pike (*Esox lucius*).
23. Scale of dace (*Leuciscus vulgaris*).

25. Leech (*Hirudo medicinalis*), anterior sucker of.
26. Leech, jaw of, side view. *a*, *b*, teeth; *c*, fibro-cartilaginous substance of jaw; *d*, pigment-cells.
27. Leech, jaw of, the free margin turned towards the observer.
28. Leech, teeth of. *a*, side view; *b*, front view.
29. Horn of cow. *a*, section parallel to surface; *b*, cells softened by potash; *d*, containing pigment; *e*, perpendicular section; *f*, cracks between laminæ; *g*, edges of divided laminæ.
30. Whalebone, longitudinal section.
31. Whalebone, transverse section.
32. Whalebone, longitudinal section of hair of.
33. Whalebone, cells of, resolved by potash.
34. Fish, crystals from scales of.
35. Muscular fibres of lobster (*Astacus marinus*).
36. Muscular fibrillæ, various appearances presented by (p. 525).
37. Large spine of skate, outer portion of.

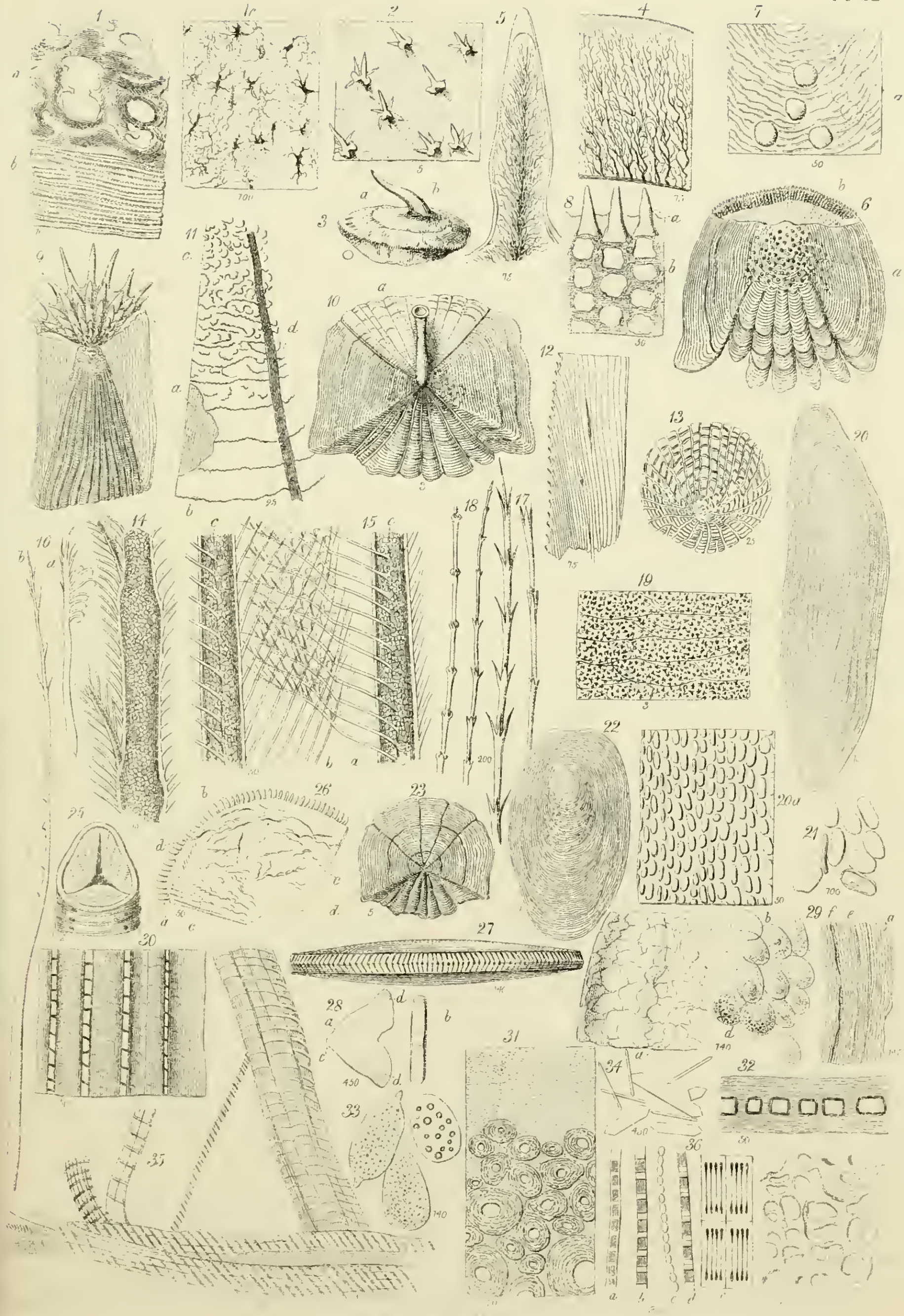

PLATE 23.—Foraminifera, etc.

Figure

1. *Miliola obesa* (young or "Adelosine" condition).
2. *Uniloculina indica.* *a,* side view; *b,* end view.
3. *Biloculina ringens.*
4 *a, b. Triloculina trigonula.*
5. *Quinqueloculina seminulum, a, b.*
6 *a, b. Quinqueloculina Brongniartii.*
7. *Spiroloculina planulata.*
8. *Hauerina compressa, a, b.*
9. *Articulina gibberula, a, b.*
10. *Vertebralina striata.*
11. *Peneroplis pertusus, a, b.*
12. *Spirolina austriaca, a, b.*
13. *Cornuspira foliacea,* magn. 8 diameters.
14. *Trochammina incerta,* magn. 25 diameters.
15. *Alveolina fusiformis.*
16. *Alveolina rotella, a, b.*
17. *Orbitolites complanatus, a, b.* *b,* natural size.
18. *Lituola difformis,* side view, somewhat abraded.
19. *Orbiculina adunca.*
20. *Valvulina austriaca.*
21. *Nubecularia rugosa, a, b.*
22. *Lagena lævis*; *b,* transverse section.
23. *Entosolenia globosa, a, b.*
24. *Lagena striata* (apiculate).
25. *Lagena semistriata.*
26. *Lagena squamosa.*
27. *Lagena scalariformis.*
28. *Glandulina lævigata, a, b.*
29. *Nodosaria raphanus,* var.
30. *Marginulina raphanus.*
31. *Marginulina raphanus* (inside of the shell).
32. *Marginulina raphanus* (sarcode, without the shell).
33. *Dentalina communis.*
34. *Cristellaria simplex.*
35. *Vaginula badenensis, a, b.*
36. *Orthocerina quadrilatera, a, b.*
37. *Cristellaria cultrata, a, b.*
38. *Flabellina rugosa, a, b.*
39. *Frondicularia spathulata* (fragment).
40. *Polymorphina communis, a, b.*
41. *Polymorphina Orbignii* (*tubulosa*).
42. *Polymorphina oblonga.*
43. *Polymorphina compressa.*
44. *Uvigerina pygmæa.*
45. *Cassidulina lævigata, a, b.*
46. *Bulimina pupoides.*
47. *Textularia cuneiformis, a, b.*
48. *Gaudryina pupoides, a, b.*
49. *Vulvulina gramen, a, b.*
50. *Bigenerina agglutinans, a, b.*
51. *Clavulina* (*Valvulina*) *parisiensis, a, b.*
52. *Textularia annectens.*
53. *Dactylopora eruca.*
54. *Dactylopora reticulata.*
55. *Polystomella crispa,* the body (sarcode) of.
56. Coccospheres, *a*; coccoliths, *b, c, d*; highly magnified.

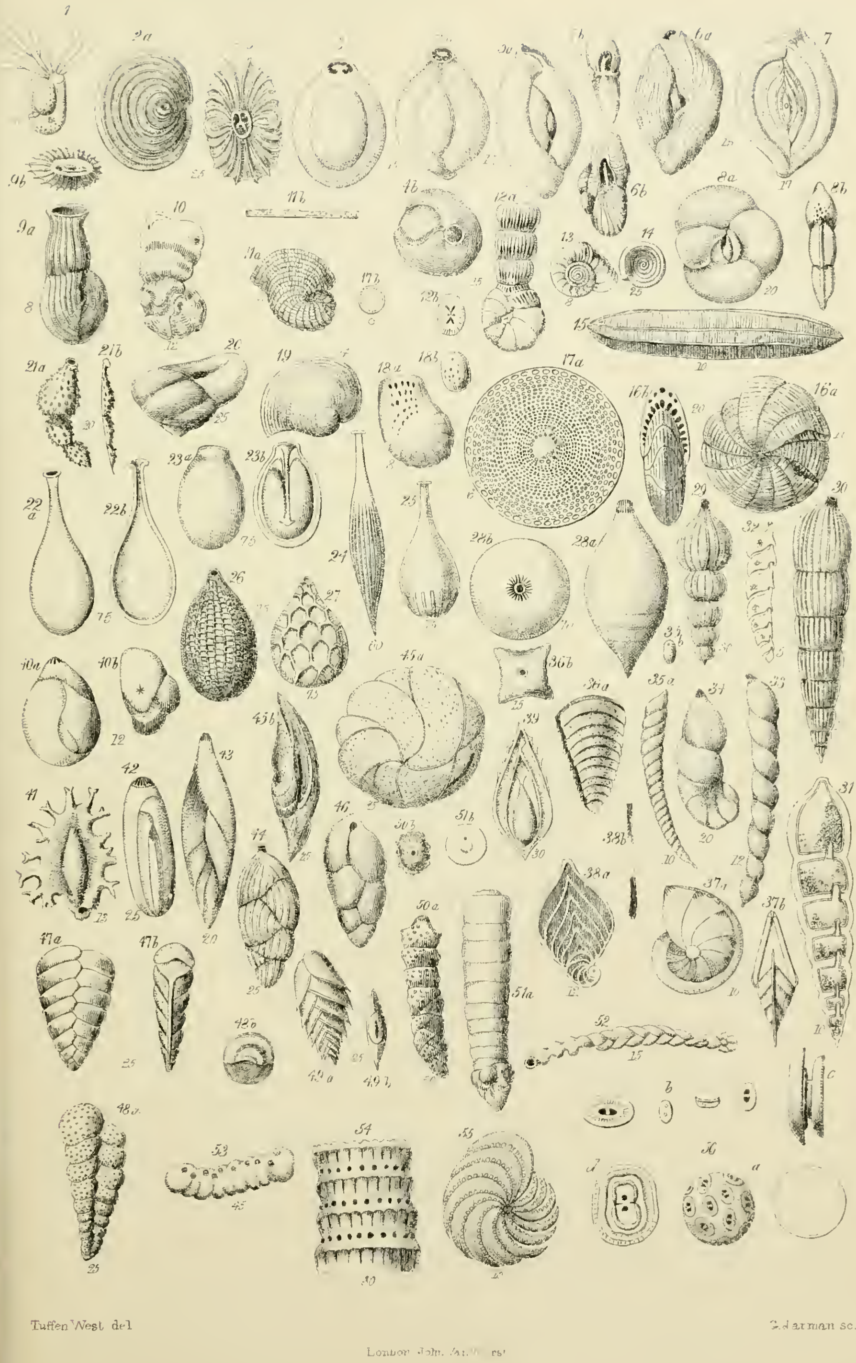

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PLATE 24.—Foraminifera.

Figure

1. *Orbulina universa.*
2. *Globigerina bulloides.*
3. Ditto, seen by transmitted light, with air in the cells.
4. *Sphæroidina austriaca.*
5. *Spirillina perforata.*
6. *Planorbulina Haidingeri, a, b.*
7. *Discorbina rosacea, a, b.*
8. *Patellina corrugata.*
9. *Truncatulina lobatula, a, b.*
10. *Planorbulina mediterranensis.*
11. *Pulvinulina vermicularis.*
12. *Planorbulina veneta* (living).
13. *Rotalia Beccarii, a, b.*
14. Ditto ; sarcode, without shell.
15. *Fusulina cylindrica, a, b, c.*
16. *Pulvinulina repanda, a, b, c.*
17. *Cymbalopora Poyei, a, b.*
18. *Nonionina crassula, a, b.*
19. *Polystomella striato-punctata.*
20. *Polystomella crispa, a, b.*
21. *Nummulites radiata, a, b.*
22. *Nummulites acuta,* section.
23. *Operculina arabica,* nat. size.
24. Ditto, enlarged horizontal section of portion.
25. Ditto, enlarged transverse section of part. } (Foraminifera).
26. Ditto, portion of fig. 25, highly magnified. }
27. *Calcarina Spengleri.*
28. *Amphistegina Hauerina, a, b.*

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PLATE 25.—Fossils.

Figure

1. *Mesocena octogona.*
2. *Asteromphalus Hookerii*, side view.
3. *Hemiaulus antarcticus*, front view.
4. *Heliopelta Leeuwenhoeckii*, side view.
5. *Asterolampra marylandica*, side view.
6. *Symbolophora trinitatis*, side view.
7. *Coscinodiscus craspedodiscus*, side view.
8. *Coscinodiscus craspedodiscus*, half a valve.
9. *Climacosphenia moniligera.* *a*, side view; *b*, front view.
10. *Terpsinoe musica*, front view: side view, Pl. 19. fig. 33.
11. *Amphipentas alternans*, side view.
12. Bodies found in flint, nature doubtful (see Pyxidicula).
13. *Pyxidicula major*, front view.
14. Moss-agate. *a*, *a*, silicified fibres of sponge; *b*, gemmules; *c*, branched fibre; *d*, spicula.
15. Crystalloids of coccolithic chalk. *a*, simple rings; *b*, radiately striated rings; *c*, disks.
16. *Actinoptychus senarius.* *a*, side view; *b*, front view.
17. *Actinocyclus undulatus.* *a*, side view; *b*, front view.
18. *Campylodiscus clypeus.*
19. *Dictyocha gracilis*, oblique view.
20. *Dictyocha gracilis*, side view.
21. *Dictyocha gracilis*, front view.

22.–28. Fossil bodies from flint, so-called Xanthidia, but consisting of the sporangia of the Desmidiaceæ.

29. Vertical (radial) section of coal from Disco, consisting of Coniferous wood (*Pinus*).
30. Transverse section of the same coal.
31. Splinter of the same.
32. Vertical section of silicified wood (*Pinus*) from Virginia.
33. Vertical section of silicified wood (*Araucaria*?) from Australia.

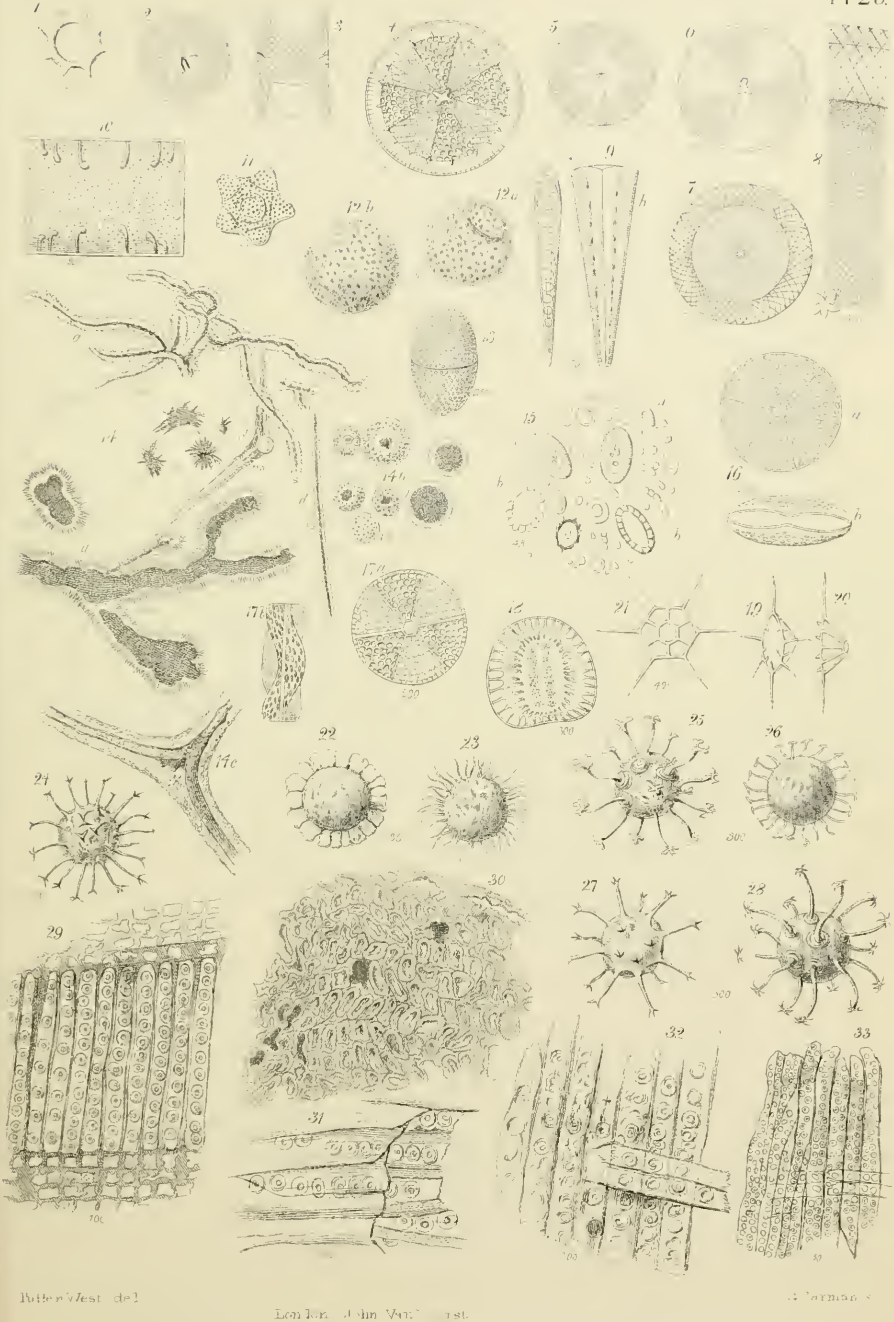

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PLATE 26.—**Fungi.**

Figure

1. Vertical section of a leaf of black currant, infested with *Æcidium grossulariæ.* *sp*, spermogonia; *p*, perithecia.
2. Sterigmata (*st*) and spermatia (*sp*) from the spermogonia of *Æcidium euphorbiæ.*
3. Ditto, from *Æcidium berberidis.*
4. Vertical section of a spermogonium of *Æcidium berberidis.*
5. *Botrytis infestans*, young plants growing out from a stoma of a potato.
6. Full-grown plants of the same. 6 *a*, spore of ditto.
7. *Torula*, growing in urine (not diabetic).
8. Grape-fungus, conidial form (*Oidium Tuckeri*) as commonly found on the leaves and fruits.

9–11. Conidia of the same, germinating.

12. Sporiferous form (*Cicinobolus*).
13. Spores from the same.
14. Hop-mildew, *Erysiphe* (*Sphærotheca*) *Castagnei.* *a*, Oidial form; *b*, *b*, form resembling *Cicinobolus*; *c*, *d*, Erysiphal form; *e*, spores.
15. Fragment from the summit of a fertile filament of *Penicillium glaucum.*
16. Spores of ditto. *a*, two still united; *b*, one detached.
17. Section of a conceptacle of *Cenangium fraxini*, containing *st*, stylospores, and *s*, spermatia.
18. Ergot of rye, *Claviceps purpurea,* Tulasne; fruits sprouting from the ergot.
19. Vertical section of the head of one of the fruits, bearing conceptacles in its periphery.
20 Vertical section of a conceptacle containing asci.
21. Asci removed from the same.
22. Spores from the interior of the asci.
23. Yeast-fungus (*Torula cerevisiæ*), large form at the bottom of liquid.
24. Ditto, minute form, appearing as a white mealy substance on the surface of stale beer.
25. *Sphæria inquinans* (*a*) with *Stilbospora macrosperma* (*b*) in the bark of an elm-tree.
26. A portion of the common matrix separating the two, with the stylospores of *Stilbospora* (*b*) above, and the asci of *Sphæria* (*a*) below.
27. Spore of *Stilbospora macrosperma.*
28. Spore of *Sphæria inquinans.*

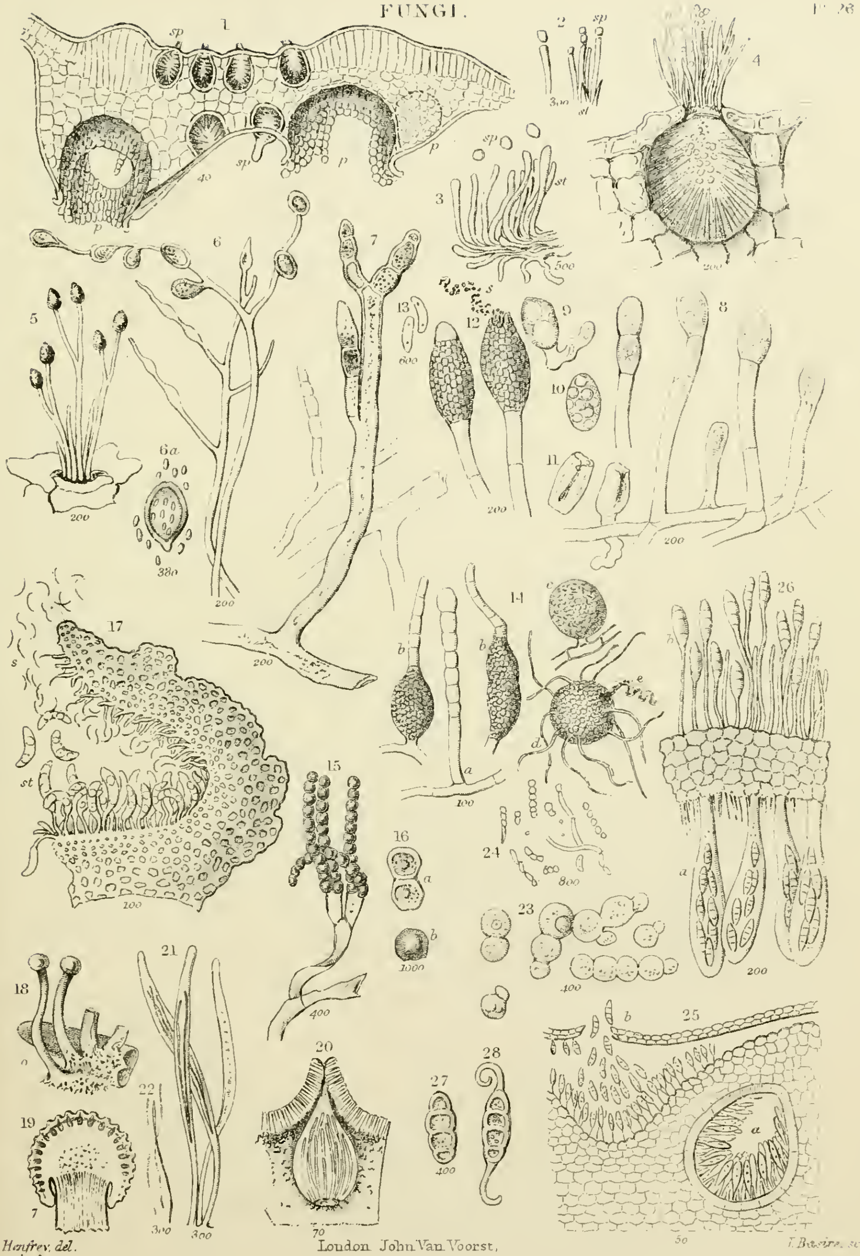

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PLATE 27.—**Fungi.**

Highly magnified.

Figure
1. Part of hymenium of *Agaricus trechispora*, with sporophores, spores, and cystidium. *a*, spore.
2. Sporophore with spores of *Agaricus nebularis.*
3. Fertile threads of *Tremella mesenterica*, with lobed sporophores and elongated spicules, one of which bears a spore.
4. Threads of the same, bearing conidia.
5. Spores of *Dacrymyces sebaceus*, producing secondary spores.
6. Sporophore of *Geaster rufescens*, with its spicules and spores.
7. Sporophore of *Cyathus striatus*, with spores.
8. Sporophore of *Rhizopogon luteolus*, with spores.
9. Threads and cysts containing spores of *Enerthenema elegans.*
10. Germinating spore and amœboid of *Stemonitis obtusata.*
11. Spores springing from the wall of the perithecium in *Hendersonia elegans.*
12. Spores of *Sporidesmium atrum.*
13. Germinating pseudo-spore of *Tilletia caries.* *a*, further development of anastomosing threads; *b*, the same producing a secondary spore.
14. Zoospore of *Cystopus candidus.*
15. Thread with spores of *Spondylocladium fumosum.*
16. *Peronospora curta.*
17. Zoospore of *Peronospora umbelliferarum.*
18. Ascus and paraphysis of *Peziza hydnicola*; *a*, conidia.
19. Stylospores of *Cenangium fraxini*; *a*, spermatia of same.
20. Conidiiferous threads of *Sphæria cupulifera*; *a*, sporidia.
21. *Mucor* (*Ascophora*) *rhizopogonis*, with an entire and ruptured vesicle with its columella; *a*, spores of same.
22. End of filament of male plant of *Saprolegnia dioica.*
23. Spermatozoids.
24. Oogonium of same.
25. Tip of male plant of the same, producing globular bodies filled with spermatozoids.
26. Young oogonium of the same, with antheridium attached.
27. Zoospore of *Saprolegnia lactea.*

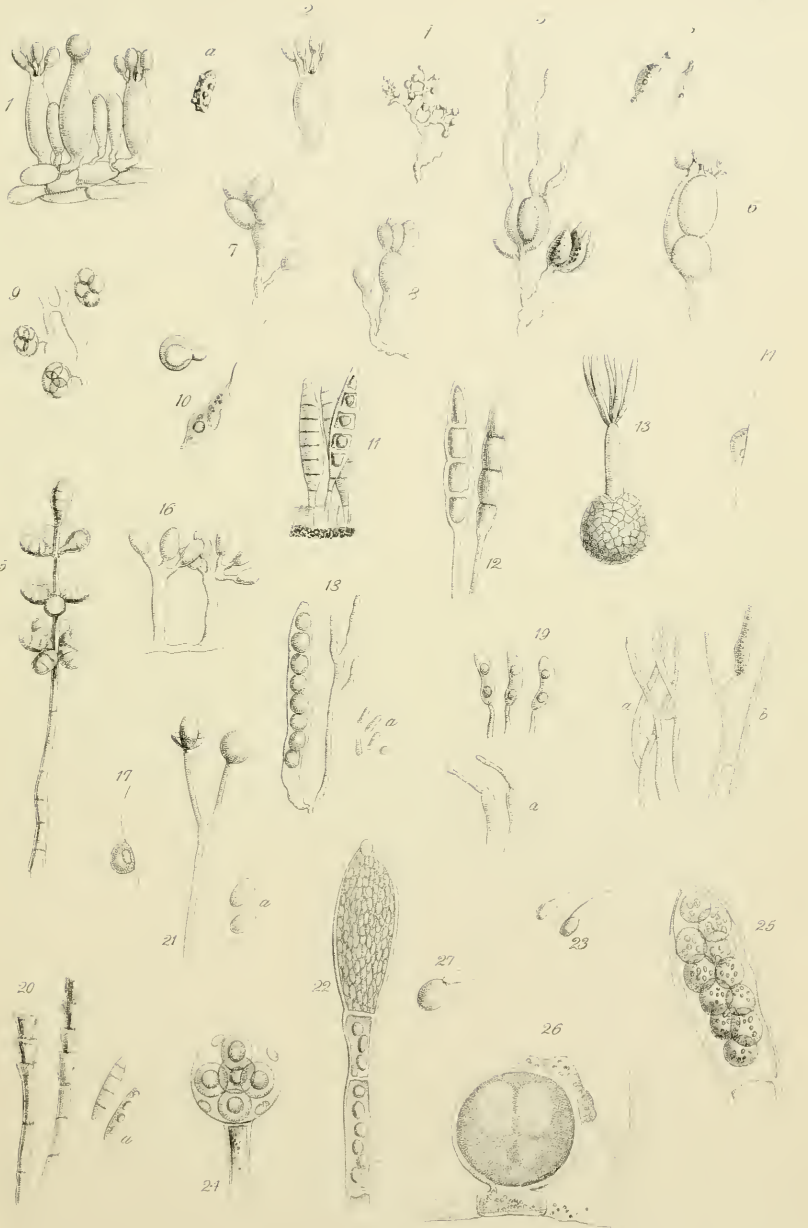

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PLATE 28.—Hairs, Fibres, Glands, &c. of Plants.

Figure
1. Cotton. *a*, normal condition; *b*, portion treated with sulphuric acid and iodine; *c*, a fragment of gun-cotton; *d*, transverse section of cotton-fibre.
2. Flax. *a*, normal fibre; *b*, portion boiled with nitric acid; *c*, treated with nitric acid, and afterwards with sulphuric acid and iodine.
3. Jute. *a*, normal fibre; *b*, *c*, portions boiled with nitric acid.
4. Coir (cocoa-nut fibre), bundle of fibres.
5. Ditto. *a*, *b*, portions of fibres boiled with nitric acid.
6. Hemp. *a*, normal fibre; *b*, portions boiled with nitric acid.
7. Manilla hemp. *a*, normal fibres; *b*, fragment boiled with nitric acid.
8. Sting of *Urtica urens.*
9. Surface of the cuticle of *Helleborus fœtidus.*
10. Ditto of *Cakile americana.*
11. Imbedded gland of *Ruta graveolens*, vertical section.
12. Glands of *Magnolia*, seen from above.
13. Hair of *Siphocampylus bicolor*, the cuticle detached by sulphuric acid.
14. Glands of hop. *a*, side view; *b*, from above.
15. Stellate body from the air-spaces in the leaf of *Nuphar lutea.*
16. Hair of *Delphinium pinnatifidum.*
17. Hair of *Anchusa crispa.*
18. Hair of *Pelargonium.*
19. Branched hair of *Verbascum Thapsus.*
20. Scale-like hairs from the seed of *Cobœa scandens.*
21. Annulated hairs from the seed of *Ruellia formosa*, in water; *b*, detached cell-wall.
22. Spiral-fibrous hairs from the seed of *Collomia grandiflora*, in water. *b*, *c*, fragments showing the cell-wall and free fibre.
23. Hair from the seed of a *Salvia.*
24. Hair from the seed of *Acanthodium spicatum.* *b*, a fragment of a branch.
25. Chinese grass-cloth fibre. *a*, normal fibre; *b*, fragments boiled with nitric acid; *c*, afterwards treated with sulphuric acid and iodine.
26. Puya fibre. *a*, normal fibre; *b*, fragments boiled with nitric acid; *c*, afterwards treated with sulphuric acid and iodine.

26*. Stellate hairs from the epidermis of *Deutzia scabra.*

27. Stellate hair of ivy-leaf.
28. Stellate hair of *Alyssum.*
29. Horizontal stalked hair of *Grevillea lithidophylla.*
30. T-shaped hair of garden *Crysanthemum.*
31. Ramentum or scale from a germinating fern.
32. Hair from the bulbil of *Achimenes.*
33. Hair from the corolla of *Digitalis purpurea.*
34. Hair from the corolla of *Antirrhinum majus.*
35. Branched hair from the epidermis of *Sisymbrium sophia.*
36. Forked hair from *Capsella bursa-pastoris.*
37. Branched hair of *Alternanthera axillaris.*
38. Gland of *Dictamnus fraxinella.*
39. Epidermis of *Dictamnus fraxinella.* *a*, *b*, hairs; *c*, gland vertically divided.
40. Glandular hair of *Lysimachia vulgaris.*
41. Glandular hair of *Scrophularia nodosa.*
42. Glandular hair of *Bryonia alba.*
43. Scale of *Begonia platanifolia*
44. Glandular hair of *Gilia tricolor.*
45. Vertical section of papilla of *Mesembryanthemum crystallinum.*
46. Seta of a rose.
47. Tufted hair of *Marrubium creticum.*

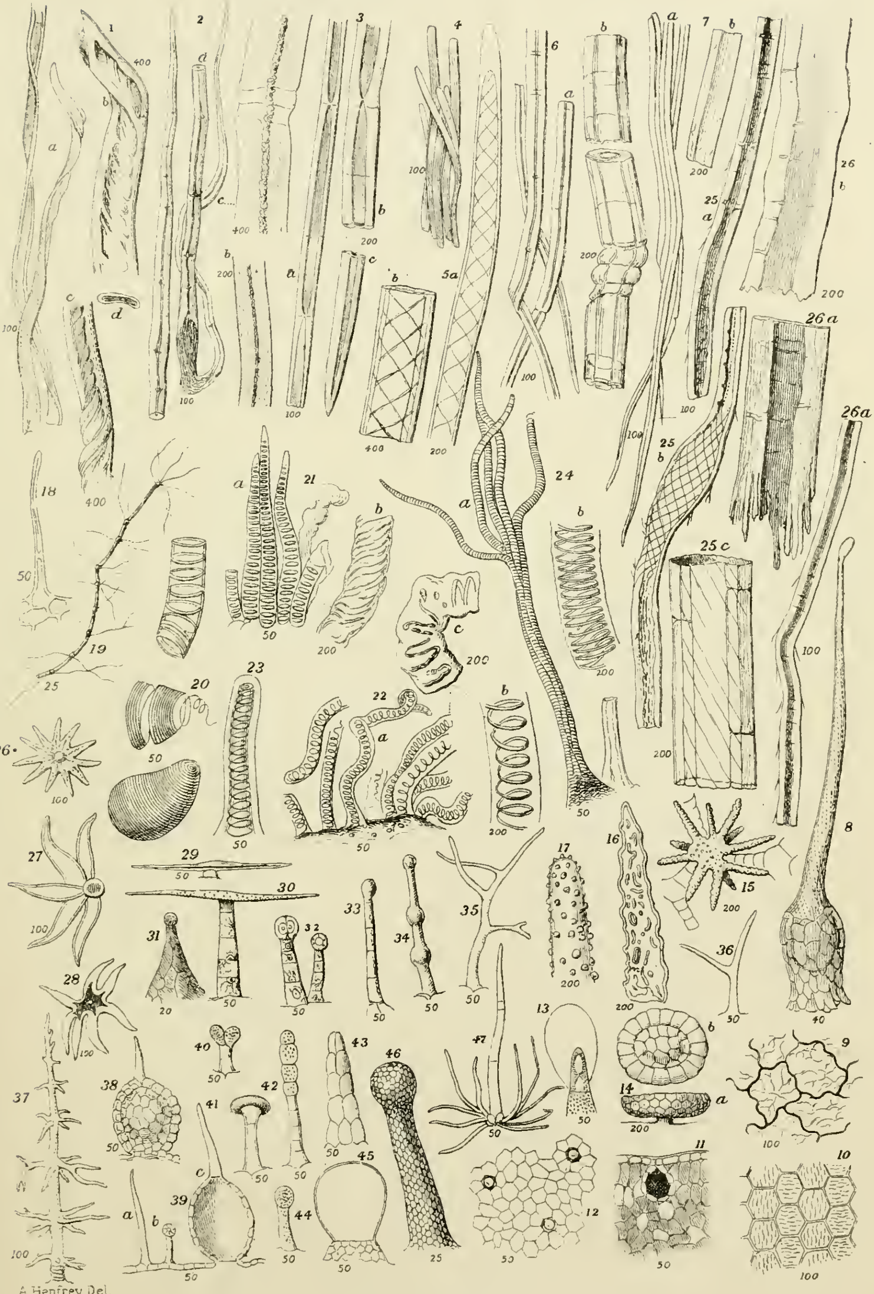

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PLATE 29.—Hairs of Animals.

Figure
1. Human whisker, white; air partly displayed from medulla.
2. Human hair, transverse sections.
3. Human hair, fœtal, with imbricated scales.
4. Monkey, Indian (*Semnopithecus*).
5. *Lemur*.
6. Bat, Indian.
7. Bat, Australian.
8. Mole (*Talpa europæa*).
9. Lion (*Felis leo*); *a*, by transmitted, *b*, by reflected light.
10. Bear (*Ursus arctos*).
11. Wolf (*Canis lupus*).
12. Coatimondi (*Nasua*).
13. Seal, Falkland-Island (*Phocæna falklandica*).
14. Horse (*Equus caballus*).
15. Elephant (*Elephas indicus*), segment of a transverse section.
16. Pig (*Sus scrofa*).
17. *Cheiropotamus*.
18. Camel (*Camelus bactrianus*).
19. Dromedary (*Camelus dromedarius*).
20. Deer, moose- (*Cervus alces*).
21. Deer, musk- (*Moschus moschiferus*).
22. Wool, sheep (*Ovis aries*).
23. Sloth (*Bradypus didactylus*).
24. Armadillo (*Dasypus sexcinctus*).
25. Beaver (*Castor fiber*).
26. Shrew (*Amphisorex rusticus*).
27. Mouse (*Mus musculus*).
28. Ditto, treated with potash.
29. Guineapig (*Cavia cobaya*).
30. Squirrel (*Sciurus vulgaris*).
31. Rabbit (*Lepus cuniculus*).
32. Sable (*Mustela zibellina*).
33. Mink-sable (*Mustela lutreola*).
34. Badger (*Meles taxus*).
35. Chinchilla (*Chinchilla lanigera*),
36. Kangaroo (*Macropus*).
37. Opossum (*Didelphys virginiana*).
38. *Ornithorhynchus paradoxus*. *a*, entire hair; *b*, *c*, *d*, and 38*, portions, more magnified.
39. Crab (*Cancer mœnas*), from antenna of.
40. Spider (*Lycosa saccata*).
41. Spider (*Mygale*).
42. Spider from South America.

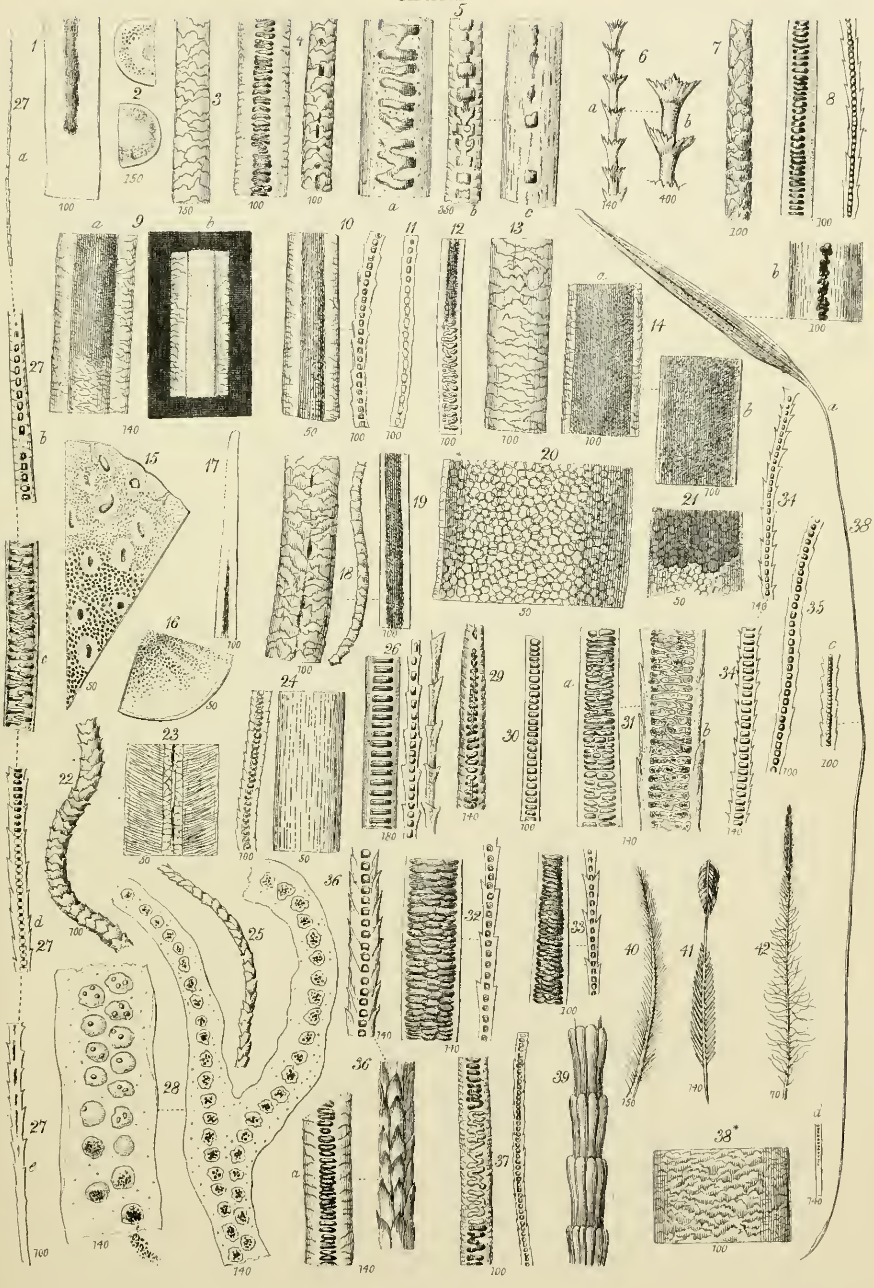

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PLATE 30.—Infusoria.

Figure
1. *Acineria incurvata,* Duj.
2. *Acineria acuta,* D.
3. *Acomia vitrea,* D.
4. *Acineta tuberosa,* Ehr.
5*a*. *Podophrya fixa,* E.; 5 *b,* the same, or the *Podophrya*-stage of *Vorticella*?
6. *Actinophrys viridis,* E.
7*a*. *Actinophrys Eichornii,* E.; 7 *b, Actinophrys sol,* E.
8. *Alyscum saltans,* D.
9. *Amœba diffluens,* E.; 9 *a,* expanded; 9 *b,* contracted.
10. *Amphileptus fasciola,* E. 10 *a,* dorsal view; 10 *b,* side view.
11. *Amphimonas dispar,* D.
12. *Anisonema sulcata,* D.
13. *Anthophysa Mülleri,* Bory, Duj. (*Epistylis vegetans,* E.); 13 *a,* entire organism; *b,* single body.
14*a*. *Arcella vulgaris,* E., dorsal view; 14 *b, Arcella aculcata,* E., under view; 14 *c, Arcella dentata,* E., under view.
15*a*. *Aspidiscus lynceus,* E., under view; 15 *b, Asp. denticulata,* E., side view.
16. *Astasia hæmatodes,* E. *a,* contracted; *b, c, d,* in different states of expansion.
17. *Astasia limpida,* D. (*A. pusilla,* E.). *a,* expanded; *b,* altered in shape.
18*a*. *Bodo grandis,* E.; 18 *b, c, Bodo socialis,* E.
19. *Bursaria vernalis,* E., under surface.
20. *Carchesium polypinum,* E.
21. *Carchesium polypinum,* E., separate body.
22. *Cercomonas acuminata,* D.
23. *Cercomonas crassicauda,* D.
24. Various forms of *Trachelomonas,* arranged by Ehrenberg in the genera *Trachelomonas, Chætoglena,* and *Doxococcus.* See TRACHELOMONAS.
25*a*. *Chætomonas globulus,* E.; 25 *b, Ch. constricta,* E.
26. *a, b, Chætotyphla armata,* E.; *c, Ch. aspera,* E.
27. *Chilodon cucullulus,* E. *a,* under view; *b,* side view.
28. *Chilomonas granulosa,* D.
29. *Chlamidodon mnemosyne,* E., ventral surface.
30. *Chlamidomonas pulvisculus,* E. (*Diselmis viridis,* D.), in various stages of development.
31. *Chlorogonium euchlorum,* E., (upper and lower figure) in different stages of development.
32. *Colacium vesiculosum,* left-hand figure; *C. stentorium,* right-hand figure.
33. *Coleps hirtus,* E. (*a,* after Ehr., *b,* after Duj.).
34. *Crumenula texta,* D.
35*a*. *Cryptoglena conica,* E.; 35 *b, Cr. pigra,* E.
36*a*. *Cryptomonas ovata,* E.; *b, C. lenticularis,* E.; *c, C. fusca,* E.; *d, C. globulus,* D.; *e, C. inæqualis,* D.
37*a*. *Cyclidium distortum,* D.; *b, C. abscissum,* D.; *c* and *d, C. glaucoma,* E.: *c,* side view; *d,* dorsal view.
38. *Cyphidium aureola,* E. *a,* dorsal view; in *b* the expansion is seen.
39. *Difflugia proteiformis,* E., *a* and *b.*
40. *Dileptus folium,* D.
41. *Dinobryon sertularia,* E.
42. *Dinobryon petiolatum,* D.
43. *Diophrys marina,* D. *a,* under view; *b,* side view.
44. *Discocephalus rotatorius,* E. *a,* dorsal view; *b,* side view.
45. *Disoma vacillans,* E.
46. *a, Distigma proteus,* E.; *b, D. viride,* E.
47. *a, Doxococcus ruber,* E.; *b, D. pulvisculus,* E.
48. *Enchelys pupa,* E.
49. *Enchelys nodulosa,* D.
50. *Epipyxis utriculus,* E.
51*a*. *Epistylis anastatica*; 51 *b,* single body of *E. branchiophila*; 51 *c,* less magnified.
52. *Ervilia legumen,* D. (*Ægyria leg.,* Cl. & L.; *Euplotes monostylus,* E.). *a,* under view; *b,* side view.
53. *Euglypha tuberculata,* D.
54. *Euglypha alveolata,* D.
55. *Amblyophis viridis,* E.

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PLATE 31.—Infusoria.

Figure

1. *Euglena pyrum*, E.
2. *Euglena viridis*, E. *a*, *b*, in different states of contraction and extension.
3. *Euglena longicauda*, E. (*Phacus longicauda*, D.), with the body twisted. Fig. 63, the same, after Duj.; the body flat.
4. *Euglena acus*, E., undergoing longitudinal division.
5. *Euplotes patella*, D. *a*, under view; *b*, lateral view.
6. *Euplotes vannus*, E., under view.
7. *Gastrochæta fissa*, D.
8. *Glaucoma scintillans*, E.
9. *Peridinium cinctum*, E.

10 *a*, *b*. *Glenodinium cinctum*, E.; 10 *c* (between figs. 49 & 50), *Glenodinium apiculatum*, E.

11. *Peridinium fuscum*, E.
12. *Peridinium tripos*, E.
13. *Peridinium fusus*, E.
14. *Glenomorum tingens*, E.
15. *Gromia fluviatilis*, D., with its expansions extended.
16. *Trichodina pediculus*, E. *a*, side view; *b*, under view.
17. *Heteronema marina*, D.
18. *Himantophorus charon*, E., under view.
19. *Himantophorus charon*, E., side view.
20. *Hexamita nodulosa*, D.
21. *Holophrya brunnea*, D.
22. *Holophrya ovum*, E.
23. *Ichthydium podura*, E.
24. *Chætonotus larus*, E.
25. *Colpoda cucullus*, E.
26. *Kerona pustulata*, D. (*Stylonichia p.*, E.).
27. *Kerona mytilus*, D. (*Stylonichia m.*, E.), under view.
28. *Kerona mytilus*, D. (*Stylonichia m.*, E.), side view.
29. *Stylonichia histrio*, E., under view.
30. *Stylonichia lanceolata*, E. *a*, under view; *b*, side view.
31. *Kondylostoma patens*, D., under view.
32. *Kondylostoma patens*, D., half side view.
33. *Trachelocerca viridis*, E.
34. *Amphileptus papillosus*, E.
35. *Lagenella euchlora*, E.
36. *Cryptomonas* (*Lagenella*, E.) *inflata*, D.
37. *Leucophrys striata*, D.
38. *Leucophrys patula*, E. *a*, dorsal, *b*, ventral surface.
39. *Loxodes rostrum*, E. (*Pelecida rostrum*, D.).
40. *Loxodes dentatus*, D.
41. *Loxodes bursaria*, E., under view.
42. *Loxophyllum* (*Amphileptus*, E.) *meleagris*, D. *a*, dorsal view; *b*, anterior portion twisted.
43. *a*, *Microglena punctifera*, E.; *b*, *M. monadina*, E.
44. *a*. *Monas lens*, D.; *b*, the same (?) with two anterior cilia; *c*, *M. attenuata*, D.
45. *Nassula elegans*, E.; *b*, teeth.
46. *Nassula aurea*, E.
47. *Opalina* (*Bursaria*, E.) *ranarum*, Purk. and Val.
48. *Ophrydium versatile*, E., portion expanded by compression.
49. *Ophrydium versatile*, E., marginal portion, in the natural state.
50. *Ophrydium versatile*, E., isolated body.
51. *Ophryoglena atra*, E.
52. *Oxytricha pellionella*, D.
53. *Oxytricha gibba*, F., side view.
54. *Oxyrrhis marina*, D.
55. *Panophrys chrysalis*, D.
56. *Paramecium aurelia*, E., dorsal view.
57. *Paramecium aurelia*, E., side view.
58. *Pantotrichum lagenula*, E.
59. *Peranema globulosa*, D.
60. *Phialina vermicularis*, E.
61. *Phialina viridis*, E.
62. *Phacus* (*Euglena*, E.) *pleuronectes*, D.
63. *Phacus* (*Euglena*, E.) *longicauda*, D.
64. *Plagiotoma lumbrici*, D.
65. *Planariola rubra*, D.
66. *Pleuronema chrysalis*, D.
67. *Plœotia vitrea*, D.
68. *Polyselmis viridis*, D.
69. *Polytoma uvella*, E.
70. *Prorocentrum micans*, E.
71. *Prorocentrum micans*, E., side view.
72. *Prorodon teres*, E.
73. *Prorodon teres*, E., teeth.
74. *Scyphidia rugosa*, E.
75. *Spathidium hyalinum*, D. (*Leucophrys spathula*, E.).
76. *Spathidium hyalinum*, D., anterior part twisted.
77. *Spirostomum ambiguum*, E.
78. *Spirostomum ambiguum*, E.; posterior end more magnified.

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PLATE 32.—Infusoria.

Figure

1. Tegument of *Paramecium aurelia*, dried, showing the depressions at different foci, &c. (INTR. p. xxxvii.)
2. *Paramecium aurelia*. *a*, with globules of sarcode; 2 *b*, free globule of sarcode, with numerous vacuoles; 2 *c*, the same, become reticular.
3. *Stentor Mülleri*, E.
4. *Tintinnus inquilinus*, E.
5. *Trachelius lamella*, D., *a* and *b*.
6. *Trepomonas agilis*, D.
7. *Trichoda angulata*, D.
8. *Trichodiscus sol*, E.
9. *Trichomonas vaginalis*, D.
10. *Trichomonas limacis*, D.
11. *Trinema acinus*, D., = *Euglypha pleurostoma*, Cart.
12. *Trochilia sigmoides*, D., ventral view.
13. *Trochilia sigmoides*, D., dorsal view.
14. *Urocentrum turbo*, E.
15. *Uroleptus piscis*, E., *a*; *b*, *U. lamella*, E.
16. *Uronema marina*, D.
17. *Urostyla grandis*, E.
18. *Uvella virescens*, E., *a* and *b*.
19. *Vaginicola crystallina*, E.
20. *Cothurnia imberbis*, E.
21. *Vorticella nebulifera*, E., *a*; 21 *b*, body separated by division; 21 *c*, body of *V. microstoma*, showing the mouth, the nucleus (auct.; testis, E.), and the contractile vesicle (vesic. seminal., E.).
22. *Zoothamnium arbuscula*, E., *a*; 22 *b*, separate body of *Z. affine*.
23. *Zygoselmis nebulosa*, D. *a*, *b*, in different states of contraction.
24. *Arcella vulgaris*, E., half side view of young, with expansions extended.
25. *Acineta*-stage of *Opercularia articulata*, E. *a*, dendritic nucleus; *b*, envelope; *c*, tentacles; *d*, vacuoles; *e*, group of fat-granules; *f*, enlarged stalk.
26. *Vorticella microstoma*, E., full-grown. *a*, œsophagus; *b*, peristome; *c*, contractile vesicle; *d*, nucleus; *e*, gemma or bud; *f*, mature bud.
27. *Vorticella microstoma*, E. (old), encysted upon its extended stalk, with its nucleus, contractile vesicle, and retracted cilia.
28. *Vorticella microstoma*, E. (young), encysted upon its contracted stalk.
29. *Vorticella microstoma*, E., encysted and stalkless. *a*, cyst; *c*, contractile vesicle; *d*, nucleus.
30. Isolated nucleus of an old *Vorticella microstoma*.
31. *Actinophrys*-stage of *Vorticella microstoma*. The cyst is partly separated from its contents; the nucleus and contractile vesicle are visible.
32. Two of the above in conjugation.
33. Two *Podophrya*-stages of *Vorticella microstoma* in conjugation.
34. Cyst of *Vorticella microstoma* discharging its brood of germs. *a*, gelatinous substance, containing *b* the germs; *c*, neck-like orifice of parent vesicle; *d*, cyst; *e*, parent vesicle.
35. *Spirochona gemmipara*, Stein. *a*, peristome with its funnel-shaped process; *b*, nucleus; *c*, gemma or bud.
36. *Acineta*-stage of the same. *a*, tentacles; *b*, nucleus; *c*, mature swarm-germ.
37. *Paramecium chrysalis*, E., undergoing longitudinal division.
38. *Glaucoma scintillans*, E., undergoing transverse division.

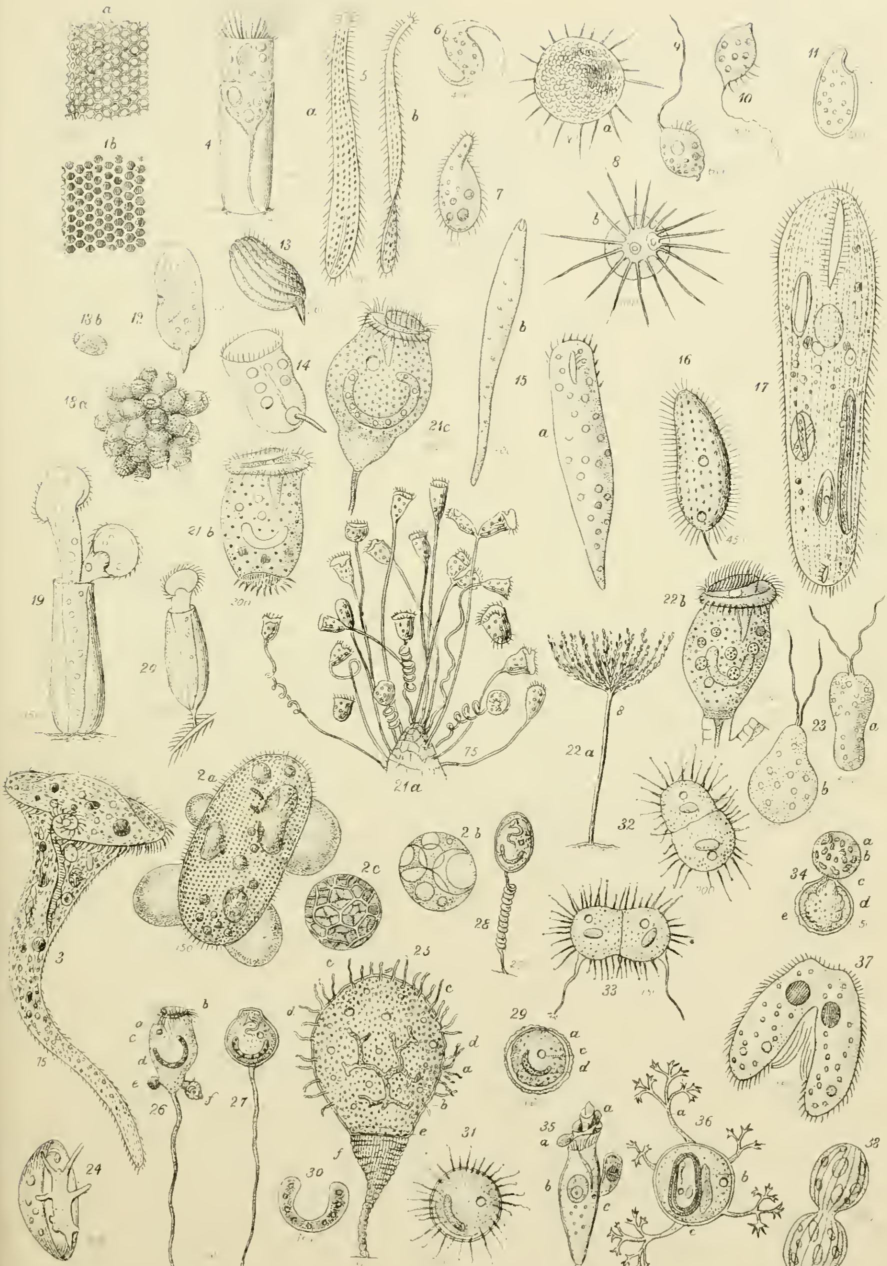

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PLATE 33.—Insects.

Figure

1. Head of *Blatta orientalis*, from before. *a*, antennæ, cut off; *b*, epicranium; *c*, eyes; *d*, clypeus; *e*, labrum; *g*, maxillæ; *h*, maxillary palpi; *k*, labial palpi.
2. Head of *Blatta orientalis*, under portion. *a*, stipes; *h*, palp of maxilla; *i*, palpiger; *k*, palp; *l*, mentum; * paraglossa of labium; *m*, submentum and gula; × occiput.
3. Head of *Hydroüs piceus*, under view. *a*, antennæ; *c*, eye; *c*, labrum; *f*, mandible; *g*, maxilla; *h*, maxillary palp; *i*, ligula; *k*, labial palp; *l*, mentum; *m*, submentum; *n*, gula; × occiput.
4. Ocelli of *Agrion fulvipes*.
5. Portions of cornea of eye of *Acheta domestica*. *a*, with hexagonal, *b*, with quadrangular facets.
6. Perpendicular section of part of the eye. *c*, faceted cornea; *g*, ganglionic expansion of *n*, the optic nerve; *r*, bacilli arising from the ganglion, surrounded by choroid pigment. 6*, corneal lenses *c*, with bacilli *r*; from eye of a beetle.
7. Antenna, setaceous (Achetidæ, &c.).
8. Antenna, ensiform (Locustidæ).
9. Antenna, filiform (Carabidæ).
10. Antenna, moniliform (Tenebrionidæ, &c.). *a*, scapus; *b*, pedicella; *c*, clavola.
11. Antenna, serrated (Elateridæ).
12. Antenna, imbricated (Prionidæ).
13. Antenna, pectinated (Lampyridæ).
14. Antenna, bipectinated (Bombycidæ).
15. Antenna, flabellate (Elateridæ).
16. Antenna, clavate (Coleoptera).
17. Antenna, capitate (Coleoptera).
18. Antenna, lamellate and perfoliate (*Melolontha*). *a*, scapus; *b*, pedicella; *c*, clavola; *d*, lamellæ.
19. Antenna of *Globaria*. *a*, scapus; *b*, pedicella; *c*, clavola; *d*, capitulum.
20. Antenna, plumose (Muscidæ).
21. Antenna, plumose (*Culex pipiens*, male).
22. Trophi of *Blatta orientalis*. *a*, labrum; *b b*, mandibles; *c*, maxillæ († lacinia, * galea); *d*, internal tongue; *e*, labium.
23. Tongue of cricket (*Acheta domestica*). *a*, *b*, *c*, parts of a fibre more magnified.
24. Head of mason-bee (*Anthophora retusa*), front view. *a*, antenna; *b*, ocelli; *c*, eye; *d*, clypeus; *e*, labrum; *f*, mandible; *g*, maxilla; *h*, its palp; *i*, palpiger or part of the ligula; *k*, labial palp; * ligula, commonly called the tongue; *x*, paraglossæ.
25. Maxillæ and labium of honey-bee (*Apis mellifica*). *g*, maxilla; *h*, its palp; *k*, labial palp; *l*, mentum; * ligula, commonly called the tongue.
26. Trophi of water-scorpion (*Nepa cinerea*). * lingua; *f*, mandibles; *g*, maxilla; *i*, labium.
27. Trophi of bug (*Cimex lectularius*). *a*, mandibles united; *b*, maxillæ; the median organ is the labium.
28. Antlia of red admiral butterfly (*Vanessa atalanta*). *a*, separate papilla; *b*, end of antlia extended; *c*, transverse section of antlia near its root; *‡ tracheæ; † tube; *a*, entire organ with two maxillæ slightly separated at the end; *e*, tooth; *f*, section near the end, showing the position of the papillæ *, and the canal ×.
29. Proboscis of the blow-fly (*Musca vomitoria*). *a*, maxillary palpi; *c*, lobes of labium. 29 *a*, portion of margin more magnified.
30. Trophi of female gnat (*Culex pipiens*). *a*, antennæ; *d*, tongue; *e*, labrum; *f f*, mandibles; *g g*, maxillæ; *i*, labium.
31. Setæ of the same, more magnified. *d*, tongue; *e*, labrum; *f*, mandible; *g*, maxilla.
32. Trophi of flea (*Pulex irritans*). *d*, labrum; *f*, mandibles or lancets; *g*, maxilla; *h*, maxillary palpi; *k*, sheaths corresponding to labial palpi.
33. Trophi of flea, more magnified. *d*, labrum; *f*, end of mandible; *k*, sheath; *l*, labium; *m*, mentum.

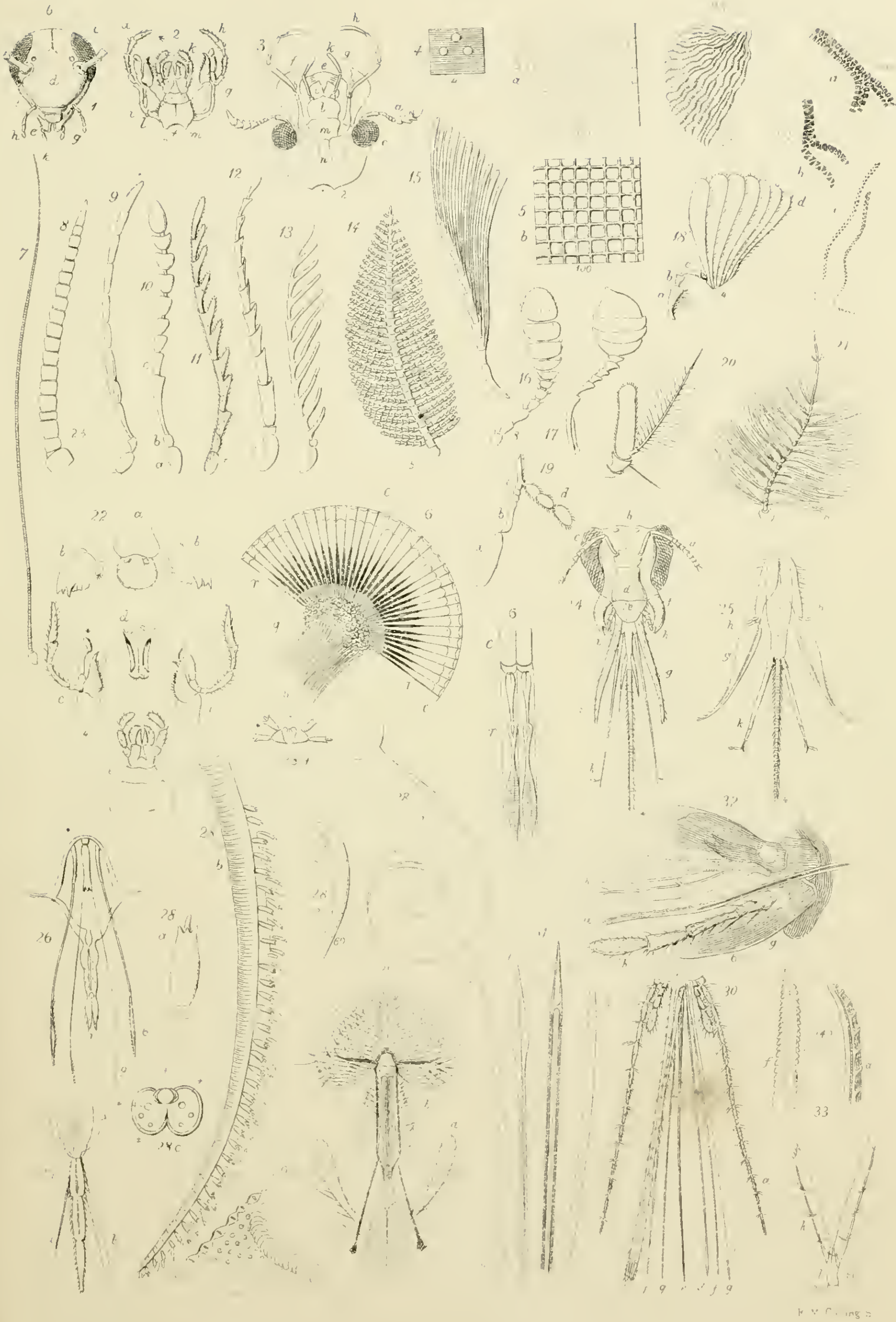

PLATE 34.—Insects.

Figure

1. Gizzard of cricket (*Acheta domestica*).

2 *a*. Under membrane of elytrum of cockchafer (*Melolontha vulgaris*); 2 *b*, separate hair or spiniform papilla (ELYTRA).

3. Scale of *Lepisma saccharina*, in liquid, showing air-bubbles imprisoned by the longitudinal ridges.

4. Hind leg of neuter honey-bee (*Apis mellifica*), with pollen-brushes on the first joint of tarsus, *a*; *c*, tibia; *d*, femur; *e*, trochanter. 4 *b*, outside of tibia hollowed out.

5. Leg of middle pair of *Gyrinus natator*. *a*, tarsus; *c*, tibia; *d*, femur; *e*, trochanter.

6. Anterior leg of male *Dytiscus marginalis*. *a*, tarsus, the first three joints with the suckers; *b*, one of the smaller ones more magnified; *c*, tibia.

7. Leg of fly (*Musca domestica*). *a*, tarsus; *c*, tibia; *d*, femur; *e*, trochanter. 7 *b*, ear of cricket.

8. Tarsal pulvillus of blow-fly, with hair-like suckers.

9. One of the hair-like suckers of the same, more magnified.

10. Anterior wing of male cricket (*Acheta domestica*). *a*, drum; *b*, file (fig. 12, the file more magnified).

11. Anterior wing of humble-bee (*Bombus terrestris*). *n*, fold over which the hooks of the posterior wing play. (See INSECTS, *wings*, and WINGS.)

12. File of cricket (compare fig. 10, *b*).

13. Costal nerve of hind wing of humble-bee (*Bombus terrestris*), with the hooks (See INSECTS, *wings*.)

14. Sting and poison-apparatus of mason bee (*Anthophora retusa*). *a*, *b*, sheath of sting; *c*, reservoir; *d*, duct; *e*, *f*, secretory organs.

15. Single sting of wasp (*Vespa vulgaris*).

16. Spinning-organs of silkworm (*Bombyx mori*).

17. Trachea of a caterpillar; lower part of the branch containing air.

18. Internal reproductive organs of male mole-cricket (*Gryllotalpa vulgaris*). *a*, testes; *b*, vasa deferentia; *c*, *c'*, prostate (blind tubes); *d*, root of penis, with cæca (Cowper's glands) at the upper part.

19. Female organs of the same. *a*, *a*, ovaries; *b*, *b*, oviducts; *c*, receptacle of semen (blind sac), the very slender tube of which, *c'*, opens into the vagina *d*.

20. Battledore scale of *Polyommatus argiolus*, dry; 20 *a*, a portion immersed in water, and more magnified.

21. A scale of the same seen in Canada balsam.

22. Scale from the wing of the gnat (*Culex pipiens*).

23 *a*. Scale from the wing of male *Pontia rapæ*, dry; 23 *b*, portion of wing of the same, showing the attachments of the two kinds of scales, *a* and *b*.

24. Scale from wing of male *Pontia brassicæ*, dry.

25. Scale from underside of wing of clothes-moth (*Tinea pellionella*).

26. Portion of wing of *Pontia brassicæ*, dry, showing the imbricated arrangement of the scales, and the wrinkling of the epidermis at their insertions.

27. Hair-like scales from clothes-moth, dry.

28 *a*. Scale from wing of *Lasiocampa quercus*, dry; 28 *b*, upper portion of the same, more magnified, dry.

29. Scale from wing of *Papilio Paris*, dry.

30. Scale from larva of *Attagenus pellio*, dry.

31. Portion of the above, more magnified.

32. End of one of the posterior legs of the larva of a *Sphinx*.

33. Anterior leg of the same.

34. Spiracle of *Dytiscus marginalis*, with one of the marginal processes more magnified.

35. Portion of outer membrane of the ovum of the blow-fly (*Musca vomitoria*).

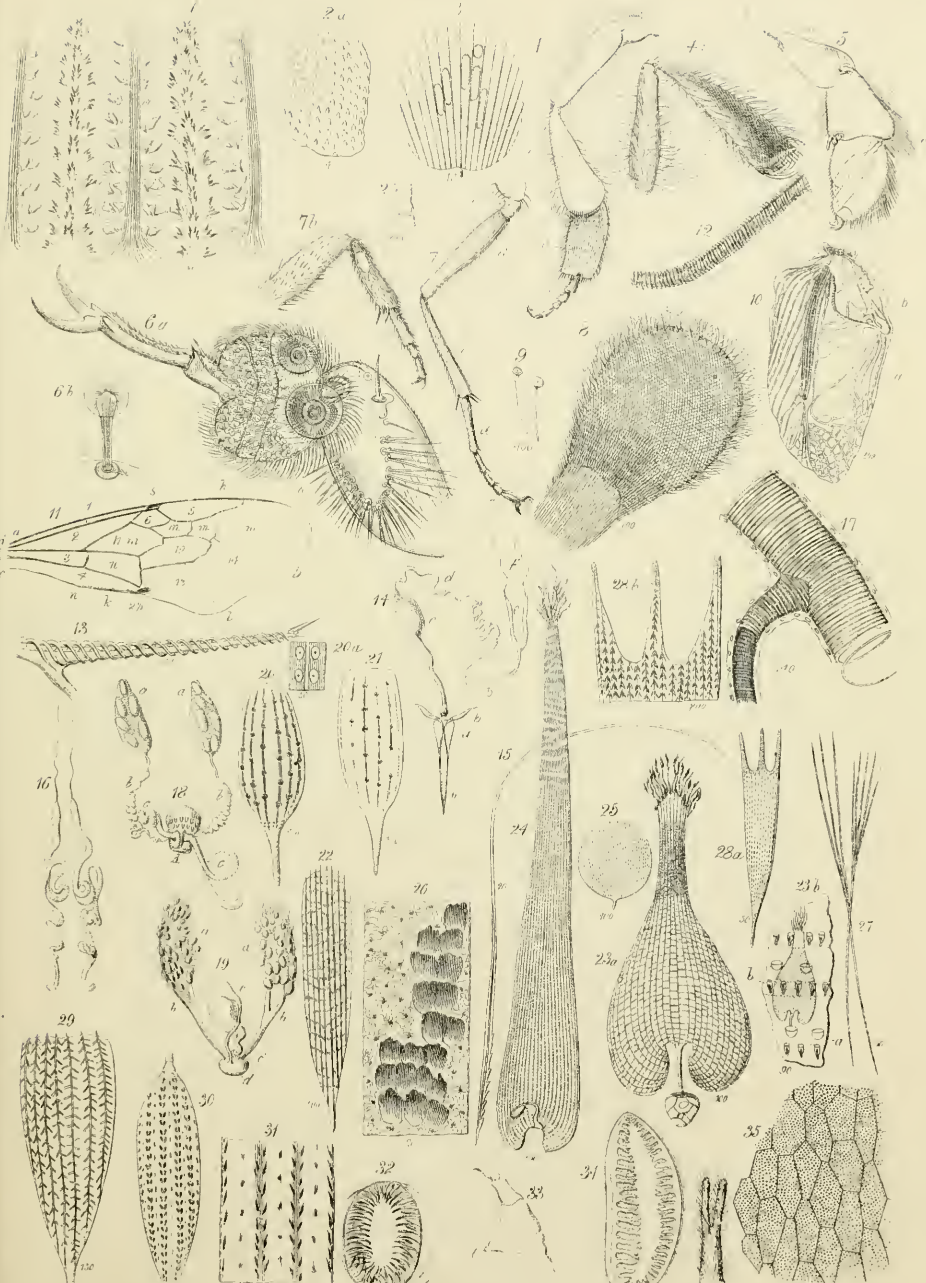

PLATE 35.—Insects.

Figure

1. Larva of gnat (*Culex pipiens*).
2. Organs of larva of *Agrion puella*. *a*, ocelli ; *b*, œsophagus ; *c*, gizzard ; *d*, stomach ; *e*, Malpighian vessels truncated ; *f*, intestine and rectum ; *g*, caudal branchiæ ; *h*, tracheæ.
3. Clothes-louse (*Pediculus vestimenti*). } ANOPLURA.
4. *Hæmatopinus suis* ; 4*, leg more magnified. } ANOPLURA.
5. *Philopterus* (*Docophorus*) *communis*. } ANOPLURA.
6. *Trichodectes latus* ; 6*, labium and labial palpi. } ANOPLURA.
7. *Liotheum* (*Menopon*) *pallidum*. } ANOPLURA.
8. *Gyropus ovalis*. } ANOPLURA.
9. *Pulex felis* (flea of cat), female. *a*, spiracles ; *b*, head ; *c*, thorax ; *d*, maxillary palpi ; *e*, setæ ; *f*, epimera ; *g*, coxæ ; *h*, trochanter ; *i*, femur ; *k*, tibia ; *l*, tarsus ; ×, pygidium ; 9 *a*, separate antenna.
10. Part of *Pulex canis* (dog's flea). *a*, prothoracic setæ ; *b*, cephalic setæ.
11. Head of flea from common bat (PULEX).
12. Antenna of flea from pigeon (PULEX).
13. Posterior end of abdomen of pigeon's flea ; male (PULEX).
14. Head of larva of *Dytiscus marginalis*. *a*, eyes ; *b*, antennæ ; *c*, mandibles ; *d*, maxillæ ; *e*, maxillary papi ; *f*, labial palpi.
15. Pupa of *Ephemera vulgata*. *a*, abdominal branchiæ.
16. Larva of *Acilius sulcatus* (formerly *Dytiscus sulc.*).
17. Pupa of *Agrion puella* (LIBELLULIDÆ) ; 17*, caudal branchial plate.
18. *Lepisma saccharina*.
19. Larva of *Gyrinus natator*.
20. Rectum of *Æschna grandis* ; 20*, portion more magnified (LIBELLULIDÆ).
21. Pupa of *Calepteryx virgo*.
22. End of abdomen of *Libellula ferruginea*.
23. Sheep-tick (*Melophila ovinus*).
24. Flea of the mole (PULEX).
25. Head of *Geophilus longicornis* (one of the MYRIAPODA).
26. Head of a *Lithobius* (one of the MYRIAPODA).
27. Fibres of silk-worm's silk.
28. Three lobes of the fatty body of the larva (caterpillar) of *Saturnia carpini*.
29. End of abdomen of *Æschna grandis*.
30. Epidermis of cricket (*Acheta domestica*).
31. Fat-body of *Ichneumon*-larva, developing from cells.
32. Egg of an aquatic insect (?) common in bog-water.

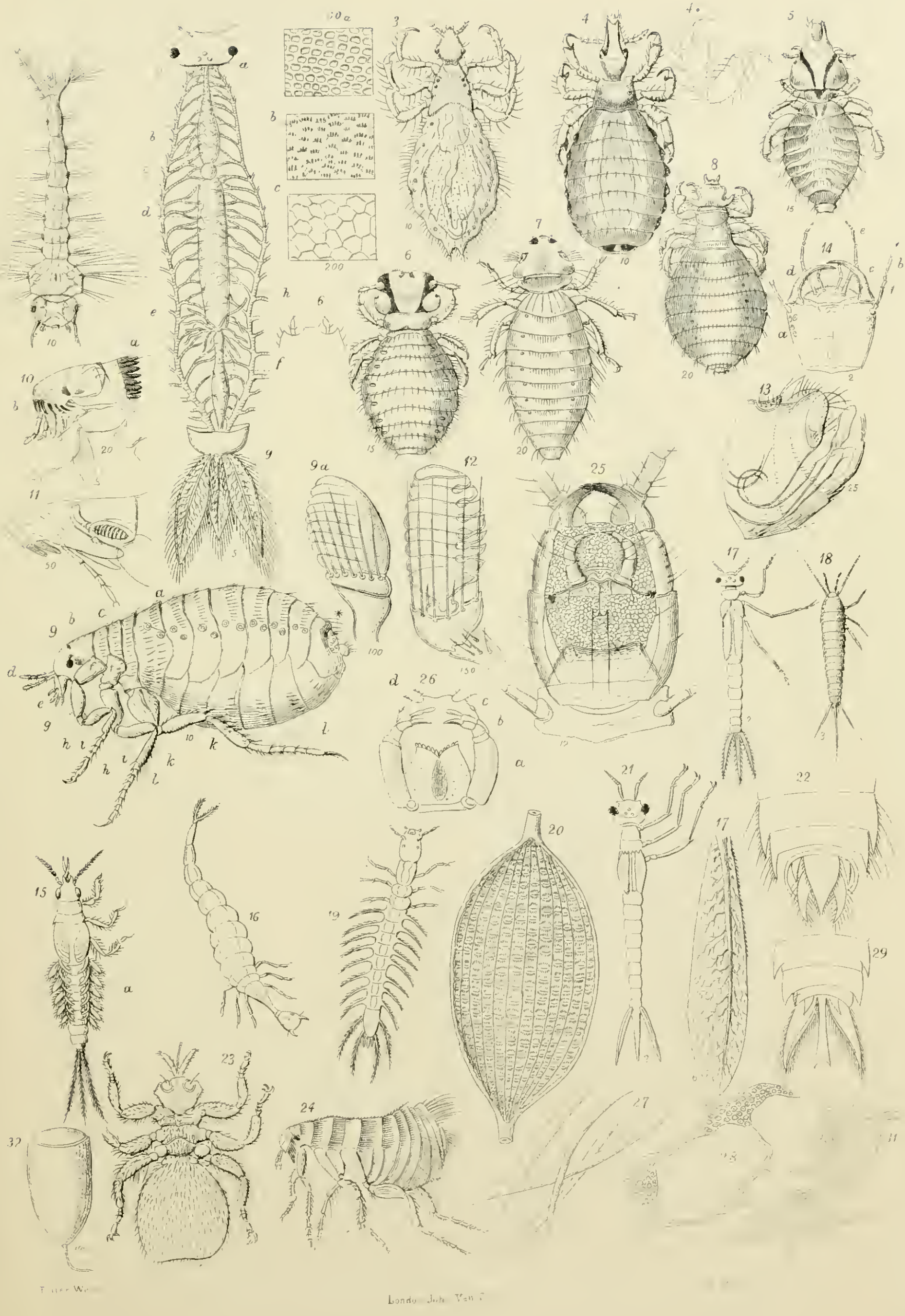

PLATE 36.—Insects, etc.

Figure

1. *Lachnus*, head of, from below (Aphidæ).
2. *Aphis*, head of, from above (Aphidæ).
3. *Aphis brassicæ* (Aphidæ).
4. *Tetraneura ulmi* (Aphidæ).
5. *Pemphigus bursarius* (Aphidæ)
6. *Trama radicis* (Aphidæ).
7. *Forda formicaria* (Aphidæ).
8. *Chalcidite*, head of (Chalcididæ).
9. *Chalcidite*: *a*, under surface of abdomen of female (Chalcididæ); *b*, separate ovipositor.
10. *Eulophus nemati*, larva of (Chalcididæ).
11. *Eulophus nemati*, pupa of (Chalcididæ).
12. *Encyrtus atricollis* (Chalcididæ).
13. *Eulophus pectinicornis* (Chalcididæ).
14. *Callimome cynipis* (Chalcididæ).
15. *Cynips*, section of abdomen of female (Cynipidæ).
16. *Rhodites rosæ* (Cynipidæ).
17. *Cynips folii* (Cynipidæ).
18. *Teras terminalis* (Cynipidæ).
19. *Neuropterus longipennis* (Cynipidæ).
20. *Ibalia cultellata* (Cynipidæ).
21. *Notamia bursaria*.
22. *Actinodiscus Barbadensis*.
23. *Distoma rubrum*: *a*, portion of common mass; *b*, individual body.
24. *Eucratea* (*Scruparia*) *chelata*.
25. *Salpingia Hassallii*.
26. *Gemellaria loricata*.
27. *Limnoria terebrans*.
28. *Monactinus duodenarius*.
29. *Spirorbis nautiloides*: *a* on seaweed; *b*, magnified.

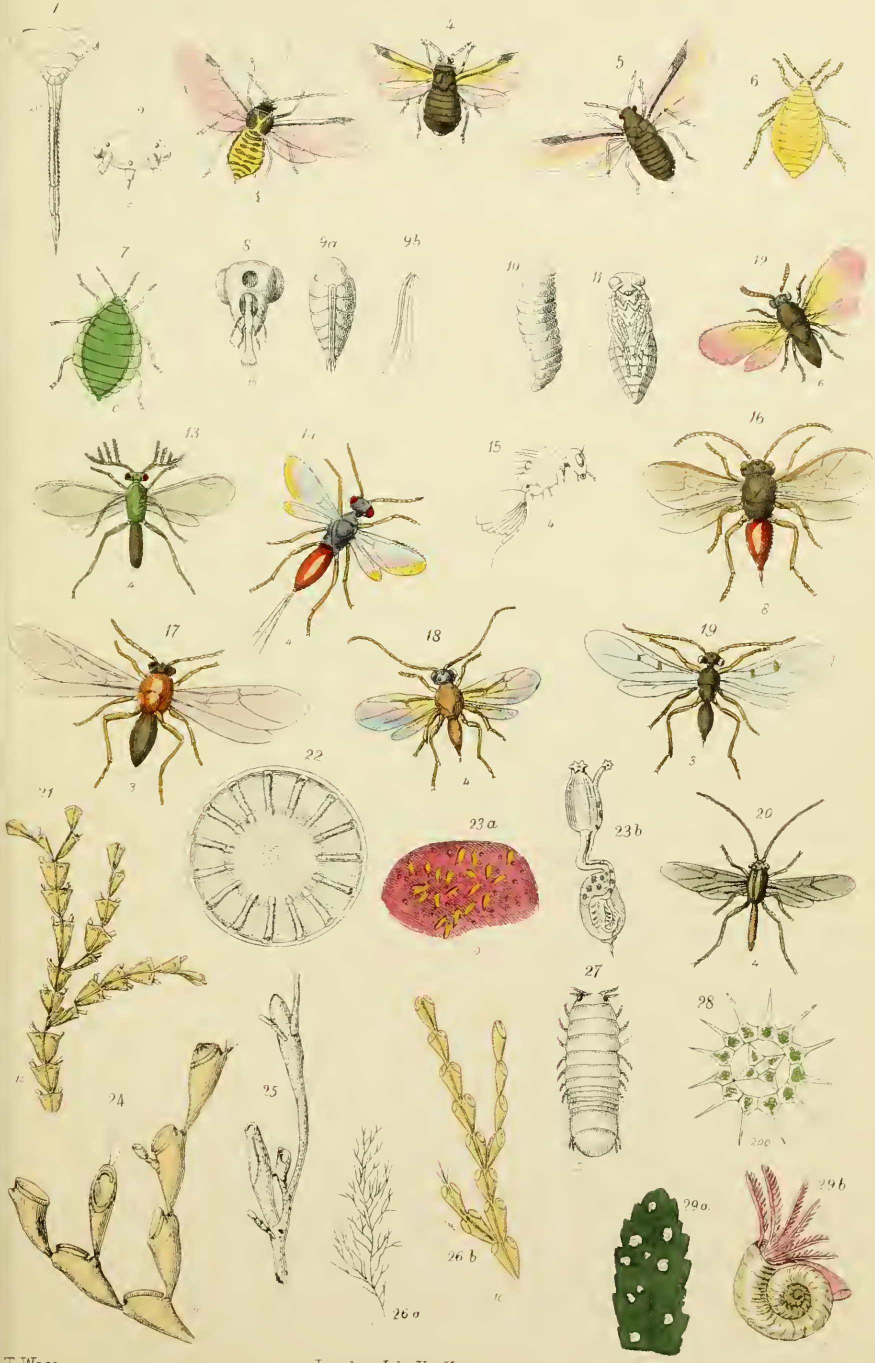

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PLATE 37.—Lichens.

Figure

1. Fragment of the thallus of *Parmelia* (*Physcia*) *parietina*, Ach., with young *apothecia*, and *spermogonia*, *s*, near the edges of the lobes.
2. Vertical section of one of the *spermogonia* and the part of the thallus in which it lies. This section shows the upper and lower cortical layers of the thallus, with the intermediate filamentous medulla and its globular *gonidia.*
3. Fragment from the wall of the above *spermogonium*, more magnified to show the articulated filaments (*spermatophores*) which bear the *spermatia.*
4. *Spores* of the same, treated with iodine; the dark portion represents the protoplasmic contents.
5. A *spore* which has germinated.
6. Fragment of a vertical section through the *apothecium* of *Parmelia* (*Physcia*) *stellaris*, Fr. The upper part is the fertile layer, or *thalamium*, *b*, composed of *thecæ* with *spores*, and *paraphyses*; this rests on the *hypothecium*, *h*, beneath which is a portion of the medullary layer, with *gonidia*, *g*.
7. Ripe *spores* of the same.
8. Ripe *spores*, germinated and not germinated, treated with sulphuric acid, and broken, showing the clear *endospore* inside the hard *exospore.*
9. Ripe *spore* of *Verrucaria nitida*, Fr.
10. Isolated *spermatia* from the *spermogonia* of ditto.
11. Ripe *spores* of *Peltigera horizontalis*, Hoffm.
12. Fragment of the *thalamium* of *Sphærophoron coralloides*, Pers., with *thecæ* in different stages of development, and free ripe *spores.*
13. Vertical section of a *spermogonium* of *Collema melænum* (*Jacobeæfolium*), with *spermatia* escaping. Imbedded in the thallus are the moniliform *gonidial* filaments.
14. Isolated articulated filaments from the same.
15. Isolated *spermatia* from these filaments.
16. Vertical section of a *spermogonium* of *Cladonia rangiferina*, Hoffm., with *spermatia* escaping from its orifice.
17. Ripe *spores* of *Urceolaria scruposa*, Ach., seen in water.
18. Fully developed *spores* of *Umbilicaria pustulata*, Hoffm.
19. Ripe *spores* of *Lecanora parella*, Ach.

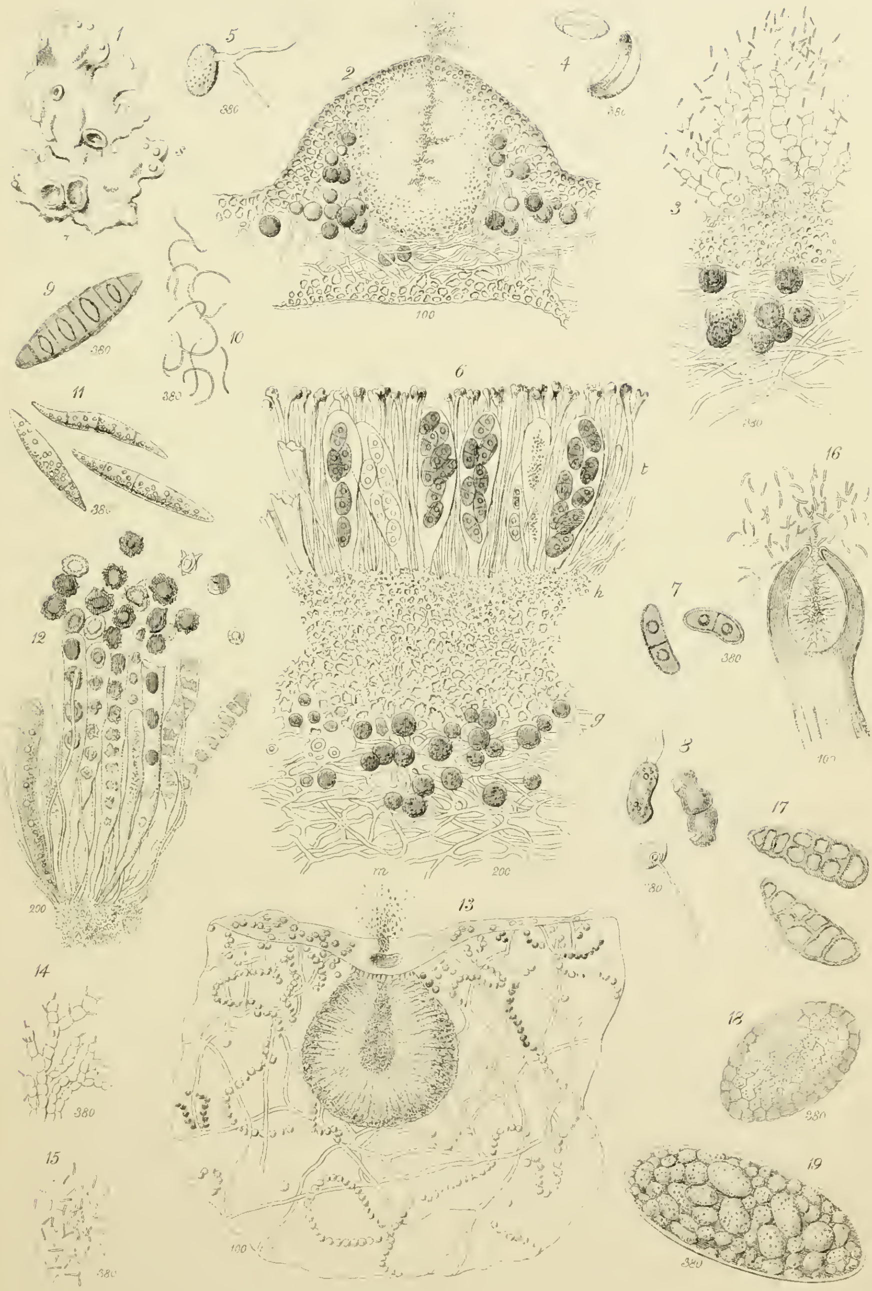

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PLATE 38.—Morbid products, human.

Figure

1. Aphtha. *a*, spores of fungus (*Oidium albicans*); *b*, fibres; *c* and *f*, *Bacterium termo*; *d*, *e*, epithelial scales; *g*, early state of *Bacterium*.
2. Areolar tissue, with formative cells and homogeneous basis; from a fibroid tumour of the upper jaw.
3. Cells of fatty tissue in degeneration. *a*, fat; *b*, nucleus; *c*, cell with thickened walls.
4. Corpuscles of pus.
5. Corpuscles of pus, treated with acetic acid. *a*, nuclei with object-glass slightly raised; *b*, the same when this is depressed.
6. Pyoid corpuscles, of Lebert.
7. Granule-cells and loose fat-globules, some of the former with distinct cell-wall and nucleus; in the lowest these are absent: from a cutaneous cancer.
8. Tubercle in lung, showing pulmonary fibres, tubercle-corpuscles, and fat-granules.
9. Tubercle-corpuscles, more magnified. *a*, seen in water; *b*, treated with acetic acid.
10. Fibroplastic cells from a sarcomatous tumour of the thigh. *a*, loose secondary cells; *b*, fusiform cells; *c*, parent cells; *d*, cell forming fibres.
11. Cancerous tissue from a medullary cancer, containing but few and pale fibres. *a*, free nucleus; *b*, nucleus within a cell.
12. Cancerous tissue from a scirrhous cancer; the fibres numerous, but delicate and not arranged in bundles.
13. Capillary vessel in a state of fatty degeneration, showing the oblong nuclei, and the minute fat-globules in the substance of the wall of the vessel.
14. *a*, fatty degeneration of the muscular bundles of the heart; the transverse striæ are absent, and globules of fat are disseminated through the substance. *b*, from muscle of the thigh, showing collapse of sarcolemma and partial absorption of muscular substance, with globules of fat in the remainder.
15. Intercellular fatty degeneration of encysted cutaneous tumour (cholesteatoma).
16. Tissue of medullary cancer of ovary. *a*, granule-cells; *b*, cancer-cells; the fibres are very few and slender.
17. Tissue of cancer of the œsophagus. *a*, cancer-cells; *b*, their nuclei (secondary cells); *c*, nucleoli (tertiary cells); *d*, cancer-cells with highly developed nuclei; *e*, granule-cells; *f*, fibres and fusiform cells.
18. Colloid or alveolar cancer of the peritoneum. *a*, nuclei or secondary cells, the walls of the two parent cells are seen at *b*; *c*, nuclei of areolar tissue; the contents of the cells are of gelatinous consistence.
19. Portion of an enchondroma, showing cells imbedded in a homogeneous basis. *a*, cell with nucleus (secondary cell) and nucleolus (tertiary cell): *c*, secondary cell with processes; *b*, secondary cell from which the primary has disappeared.

20.
21. } Cancer-cells from medullary cancer.

22. Colloid corpuscles. *a*, simple; *b*, *c*, concentric or laminated corpuscles from hypertrophied heart; *d*, *f*, laminated corpuscles from the prostate, containing calcareous matter; *e*, concentric corpuscle from a cyst in an atrophied kidney.

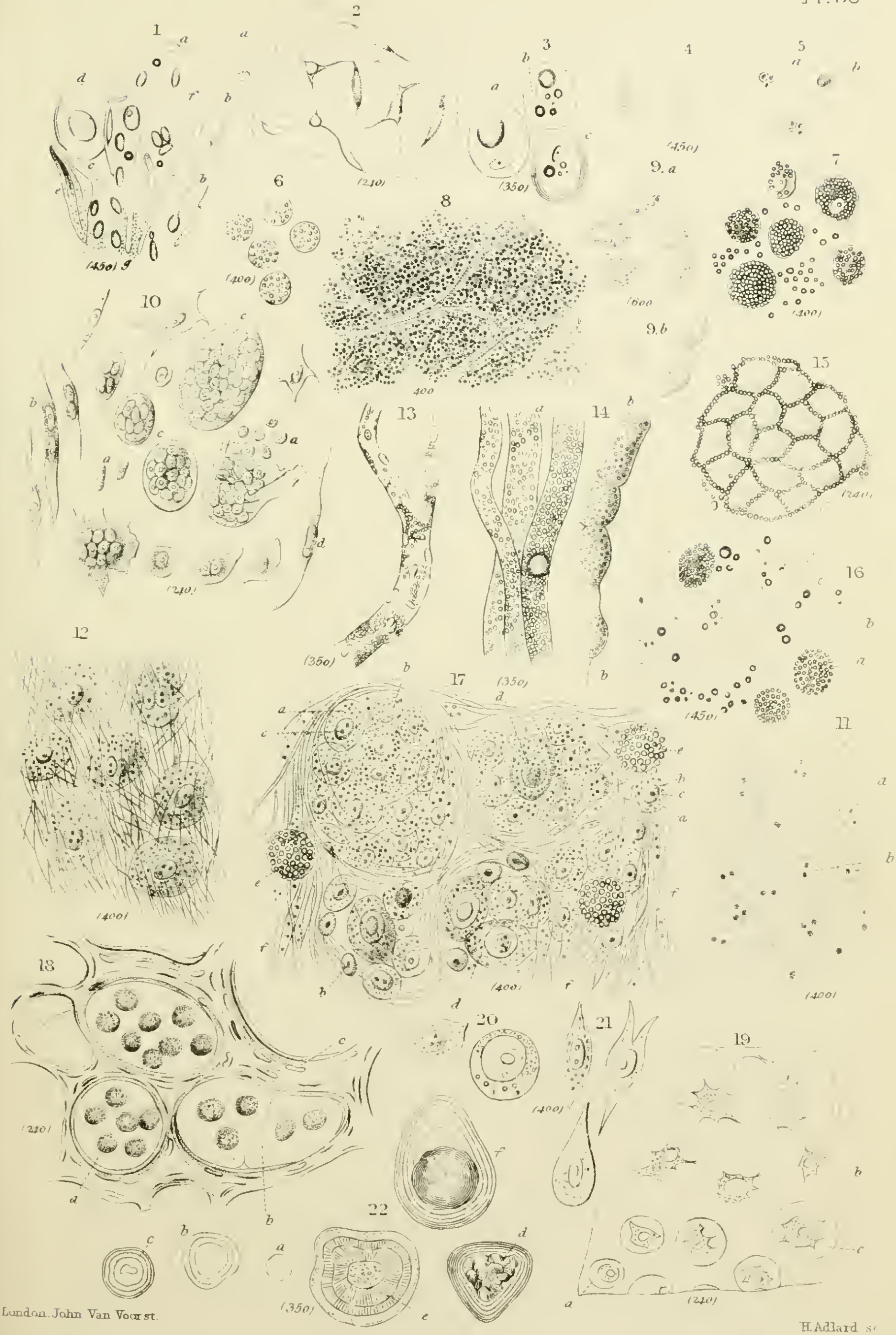

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PLATE 39.—Opaque and Polarizing Objects.

Figure

1. Two rhombs of selenite as seen under different relative positions of the polarizer and analyzer.
2. Crystals of acetate of copper (Acetic acid, Dichroism).
3. Crystals of uric acid under polarized light, natural and artificial (compare Pl. 12).
4. Prisms of ammonio-phosphate of magnesia, under polarized light.
5. Ellipsoidal-constricted, or dumb-bell crystals of oxalate of lime, under polarized light.
6. Crystals of oxalate of soda, under polarized light.
7. Crystals of oxalate of ammonia, under polarized light.
8. Crystals of oxalate of chromium and ammonia, under polarized light.
9. Crystals of salicine, under polarized light.
10. Crystals of sulphate of cadmium, under polarized light.
11. Crystals of oxalurate of ammonia, under polarized light.
12. Crystals of oxalurate of ammonia, under polarized light with a plate of selenite.
13. Elytrum of *Curculio imperialis*, as an opaque object.
14. Seed of white poppy (*Papaver somniferum*), opaque object.
15. Seed of sweet-william (*Dianthus barbatus*), opaque object.

16., 17. Seeds of *Silene gallica*, opaque objects.

18. Seeds of foxglove (*Digitalis purpurea*), opaque objects.
19. Egg of puss-moth (*Cerura vinula*), opaque object.
20. Eggs of bug (*Cimex lectularius*), opaque objects ; the lids are removed.
21. Eggs of *Pontia rapæ*, opaque objects.
22. Skin and scales of sole (*Solea vulgaris*), opaque objects.

23.–31. Polycystina. Opaque objects.

23. *Rhopalocanium ornatum*.
24. *Stephanastrum rhombus*.
25. *Eucertydium ampulla*, front view.
26. *Eucertydium ampulla*, under view.
27. *Podocyrtis Schomburgkii*.
28. *Anthocyrtis mespilus*.
29. *Astromma Aristotelis*.
30. *Lychnocanium lucerna*.
31. *Haliomma Humboldtii*.
32. Eggs of *Pontia brassicæ*, opaque objects.
33. Portion of liver of cat; the porta injected with red, the vena cava with yellow; opaque object.
34. Portion of lung of toad; opaque object.
35. Kidney of pig; arteries and Malpighian bodies red, urinary tubules white; opaque object.
36. Spiracle of *Bombyx*, opaque object.

37., 38. Sections of Rhinoceros-horn, by polarized light.

39. White hairs of horse, interlaced; by polarized light.
40. Tous-les-mois starch, by polarized light with plate of selenite.

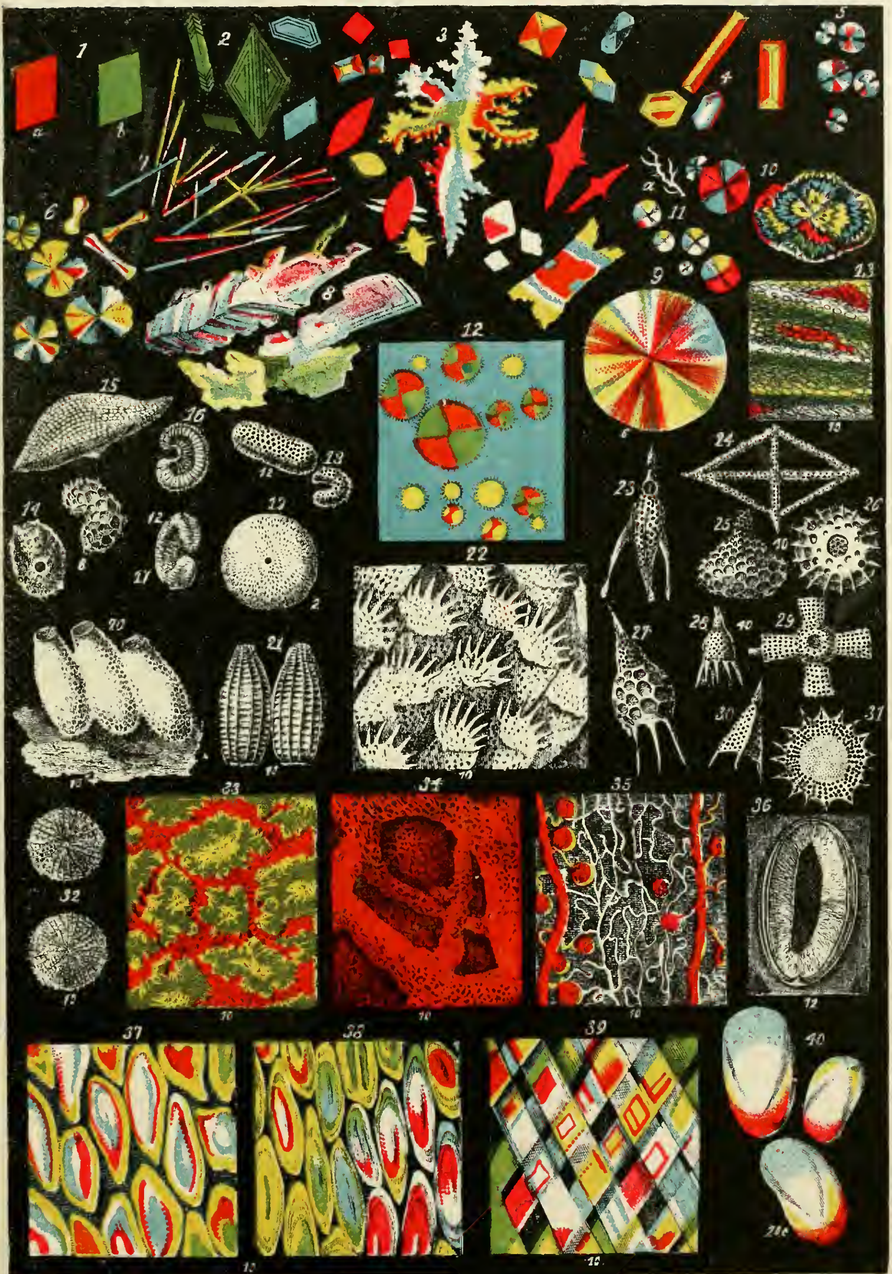

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PLATE 40.—Pollen, etc.

Figure

1. *a* and *b*, spiral tissue of lining of anther from wallflower (*Cheiranthus cheiri*).
2. Ditto, from London Pride (*Saxifraga umbrosa*).
3. Ditto, from *Lupinus nanus.*
4. Ditto, from a cactus (*Cereus speciosus*). *a*, side view; *b*, from above.
5. Ditto, from daisy (*Bellis perennis*).
6. Pollen of *Viola odorata.* *a*, side view; *b*, end view; *c*, in water.
7. Pollen of *Apocynum venetum.*
8. Pollen of daisy (*Bellis perennis*).
9. Pollen of *Mesembryanthemum.*
10. Pollen of *Alisma plantago.*
11. Pollen of *Lupinus nanus.*
12. Pollen of garden-geranium (*Pelargonium speciosum*). *a*, front view; *b*, side view.
13. Pollen of passion-flower (*Passiflora cærulea*). *a*, perfect grain; *b*, grain with the lid of a pore opening.
14. Pollen of *Epilobium montanum.*
15. Pollen of *Periploca græca.*
16. Pollen of *Pinus sylvestris.*
17. Pollen of *Erica multiflora.*
18. Pollen of *Sherardia arvensis.* *a*, side view; *b*, end view; *c*, ditto in water.
19. Pollen of *Basella alba.*
20. Pollen of *Passiflora aquilegiæfolia.* *a*, side view; *b*, end view; *c*, ditto in water.
21. Pollen of *Impatiens noli-me-tangere.*
22. Pollen of *Cucurbita pepo*, in water.
23. Pollen of *Ruellia formosa.*
24. Pollen of *Thunbergia alata*, *a*; of *Mimulus moschatus*, the musk-plant, *b*.
25. Compound pollen of *Acacia laxa.*
26. Pollen of *Hibiscus trionum.*
27. Pollen of chicory (*Cichorium Intybus*).
28. Pollen of *Sonchus palustris*, side and end views.
29. Pollen of *Statice linifolia*, end and side views.
30. Pollen-grain with tube upon the stigmatic papillæ, from *Lathræa squamaria.*
31. Spermatozoid from the globule of *Chara fragilis.*
32. Spermatozoids from the antheridium of *Marchantia polymorpha.*
33. Spermatozoids from the antheridium of *Polytrichum commune.*
34. Spermatozoids from the antheridium of a Fern (*Gymnogramma*).
35. Spiral-fibrous cells of the sporange of *Marchantia polymorpha.*
36. Elater of *Marchantia polymorpha.*
37. Fragments of ditto. *a*, from the middle; *b*, one end.
38. Elater of *Frullania dilatata.*
39. Elaters (*a*) and spores (*b*) of *Trichia.*
40. Fragment of the same elater showing the three internal spiral fibres.

POLLEN, ETC. Pl. 40.

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PLATE 41.—Polypi and Polyzoa.

Figure

1. Areolar tissue of sea-anemone (*Actinia mesembryanthemum*); with spicula, cells, and fibre-cells.
2. Spicula from the same.
3. *Alcyonella stagnorum.* *a*, entire polyzoary; *b*, perpendicular section, showing tubes and ova; *c*, back view of polype with tentacles; *d*, ova.
4. *Campanularia volubilis.* *a*, growing upon a piece of *Plumularia falcata*; *b*, portion of polypidom more magnified; 4 *c*, cell of *Laomedea dichotoma* with ova; *d*, medusa-germ or gonozoid of *Clytia.*
5. *Canda* (*Cellularia*) *reptans*, portion of polypidom of. 5 *a*, *Bicellaria* (*Cellularia*) *ciliata*; 5 *b*, the same more magnified, * a bird's-head process; 5 *c*, posterior view of a cell of *Canda reptans*, with its appendices; 5 *d*, three appendices to a cell of the same; 5 *e*, polype expanded; 5 *f*, perforated septum.
6. *Corallium rubrum*; axis with polypiferous crust.
7. Spicula from the crust.
8. *a*, transverse section of the axis of red coral, from the furrowed exterior towards the centre; *b*, longitudinal section.
9. Body of *Cristatella mucedo.*
10. Ova of the same, seen from above.
11. Branch of *Sertularia rugosa.*
12. Portion of the same, magnified, with cells *a*, and vesicles *b*.
13. *Sertularia pumila.*
14. Portion of the same, magnified. *a*, cell; *b*, vesicle.
15. *Sertularia operculata.*
16. Portion of the same, magnified. *a*, cells; *b*, vesicles.
17. *Lepralia variolosa.*
18. *Membranipora pilosa.* 18*, polypes protruding from the cells; 18 *a*, cell; *b*, valve through which the ciliated tentacles *c* protrude; *d*, œsophagus; *e*, pouch containing the stomach, liver, &c.; *f*, place of gyration of particles in intestine; *g*, rectum.
19. Piece of *Flustra carbasea.*
20. Cells of the same, magnified.
21. *Hydra viridis*, attached to *Lemna.*
22. Stinging organs of *Hydra vulgaris.* *a*, capsule with the spines and filament enclosed; *b*, capsule with the spines and filament protruded; *c*, very minute capsules; *d*, capsule imbedded in a globule of the sarcodic substance of the body.
23. Tentacle of *Hydra viridis.* *a*, stinging organs *in situ.*
24. *Hydra viridis*, with spermatic capsules *a*, and ovarian capsule *b*.
25. Ovum of *Hydra*, with the young polype bursting through its shell.
26. Bird's-head processes of *Flustra avicularis.*
27. Spiculum of a *Gorgonia.*
28. Spicula of *Alcyonium digitatum.*
29. Globules of sarcodic substance of a crushed *Hydra viridis.* *a*, one containing a small vacuole and several green granules; the latter are more magnified below; *b*, a globule greatly distended by the formation of a large vacuole.
30. *Tubulipora*, with a polype protruding from a cell.

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PLATE 42.—Rocks.

Figure

1. Fluid-lacunæ in quartz, magnified 120 diameters.
2. Glass-lacunæ in triclinic felspar. Lava of A.D. 1607; near Randazzo, Etna; 77 diams. *Crossed Nicols.*
3. Trichites in obsidian. Yellowstone district, U. S., 250 diams.
4. Crystallites in obsidian. Mexico, 30 diams.
5. Microliths (belonites) of augite, in pitchstone. Corriegills, Arran, 55 diams.
6. Spherules in obsidian. Lipari, 25 diams.
7. Perlite. Buschbad, near Meissen, Saxony, 18 diams.
8. Fluxion structure around sanidine crystals in obsidian. Lower Geyser basin, Yellowstone district, Colorado, U. S., 18 diams.
9. Granite. Cornwall, 25 diams. *Polarized light.* (Orthoclase, plagioclastic felspar, quartz, and biolite.)
10. Syenite. Hemsbach, Germany, 30 diams. *Polarizer only.* (Hornblende, orthoclase, quartz, and magnetite.)
11. Minette (mica trap). Seifersdorf, Saxony, 55 diams.
12. Felstone (hälleflinta). Schiesshyttan, Sweden, 120 diams. *Crossed Nicols.*
13. Trachyte. Drachenfels, Rhine, 55 diams. *Polarized light.* (Sanidine, oligoclase sphene, &c.)
14. Phonolite. Höhgau, Germany, 33 diams. (Nosean and hornblende.)
15. Diorite. Ontario, 55 diams. *Polarized light.* (Hornblende, triclinic felspar, apatite, &c.)
16. Basalt. Wohlbach, near Adorf, Saxony, 18 diams. *Polarized light.* (Porphyritic olivine crystals and magnetite.)
17. Basalt. Giant's Causeway, Ireland, 77 diams. *Polarized light.* (Olivine, triclinic felspar, magnetite.)
18. Basalt. Titterstone, Clee Hill, Shropshire, 77 diams. *Polarized light.* (Augite, triclinic felspar, apatite, &c.)
19. Phonolite. Wolf Rock, Cornish coast, 33 diams. (Nepheline and hornblende.)
20. Mica schist. Bräunsdorf, Saxony, 18 diams. (Biolite and quartz.)
21. Millstone grit (coarse felspathic sandstone). Black Rocks, Cromford, Derbyshire, 18 diams. *Polarized light.* (Fragments of quartz and felspar, with ferruginous cement.)
22. Slate (Cambrian). Penrhyn Quarries, North Wales, 250 diams. *Crossed Nicols.*
23. Great Oolite. Grimsthorpe Park, Lincolnshire, 18 diams.
24. Carrara marble, 33 diams. *Polarized light.*

The minerals mentioned, in brackets, form prominent objects in the drawings; but do not necessarily include all the constituents of the different rocks.

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PLATE 43.—Rotatoria.

Figure
1. *Actinurus Neptunius*, E., swimming. *a*, orifice of intestine.
2. Gizzard, with teeth of the same.
3. Head of the same, while crawling.
4. *Albertia vermiculus*, D.; 4 *a*, teeth.
5. *Anuræa curvicornis*, E., dorsal view.
6. *Anuræa curvicornis*, E., half side view.
7. *Asplanchna priodonta*; *b*, jaws and teeth.
8. *Brachionus amphiceros.*
9. *Brachionus rubens*, jaws of.
10. *Callidina elegans.*
11. *Callidina elegans*, jaws.
12. *Colurus deflexus*, dorsal view.
13. *Colurus deflexus*, under view.
14. *Colurus deflexus*, teeth.
15. *Conochilus volvox*, isolated animal.
16. *Conochilus volvox*, spherical group.
17. *Conochilus volvox*, jaws of.
18. *Cycloglena lupus.* *a*, tremulous bodies; *b*, contractile sac.
19. *Cyphonautes compressus*, side view. *a*, pharynx; *b*, nervous ganglion; *d*, intestine.
20. *Cyphonautes compressus*, end view.
21. *Diglena lacustris.*
22. *Diglena lacustris*, jaws.
23. *Dinocharis tetractis.*
24. *Dinocharis pocillum*, teeth of.
25. *Distemma forficula.*
26. *Distemma forficula*, jaws of.
27. *Enteroplea hydatina.*
28. *Eosphora digitata.*
29. *Eosphora digitata*, jaws of.
30. *Euchlanis triquetra.*
31. *Euchlanis triquetra*, jaws of.
32. *Floscularia ornata.*
33. *Floscularia proboscidea*, jaws of.
34. *Furcularia Reinhardtii.*
35. *Furcularia Reinhardtii*, jaws of.
36. *Glenophora trochus.*
37. *Hydatina senta.*
38. *Hydatina senta*, jaws of.
39. *Hydrias cornigera.*
40. *Lindia torulosa.*
41. *Lindia torulosa*, teeth of.
42. *Plagiognatha hyptopus*, D. (*Notommata hyp.*, E.).
43. *Lepadella emarginata.*
44. *Lepadella ovalis*, jaws of.
45. *Limnias ceratophylli.*
46. *Mastigocerca carinata.*

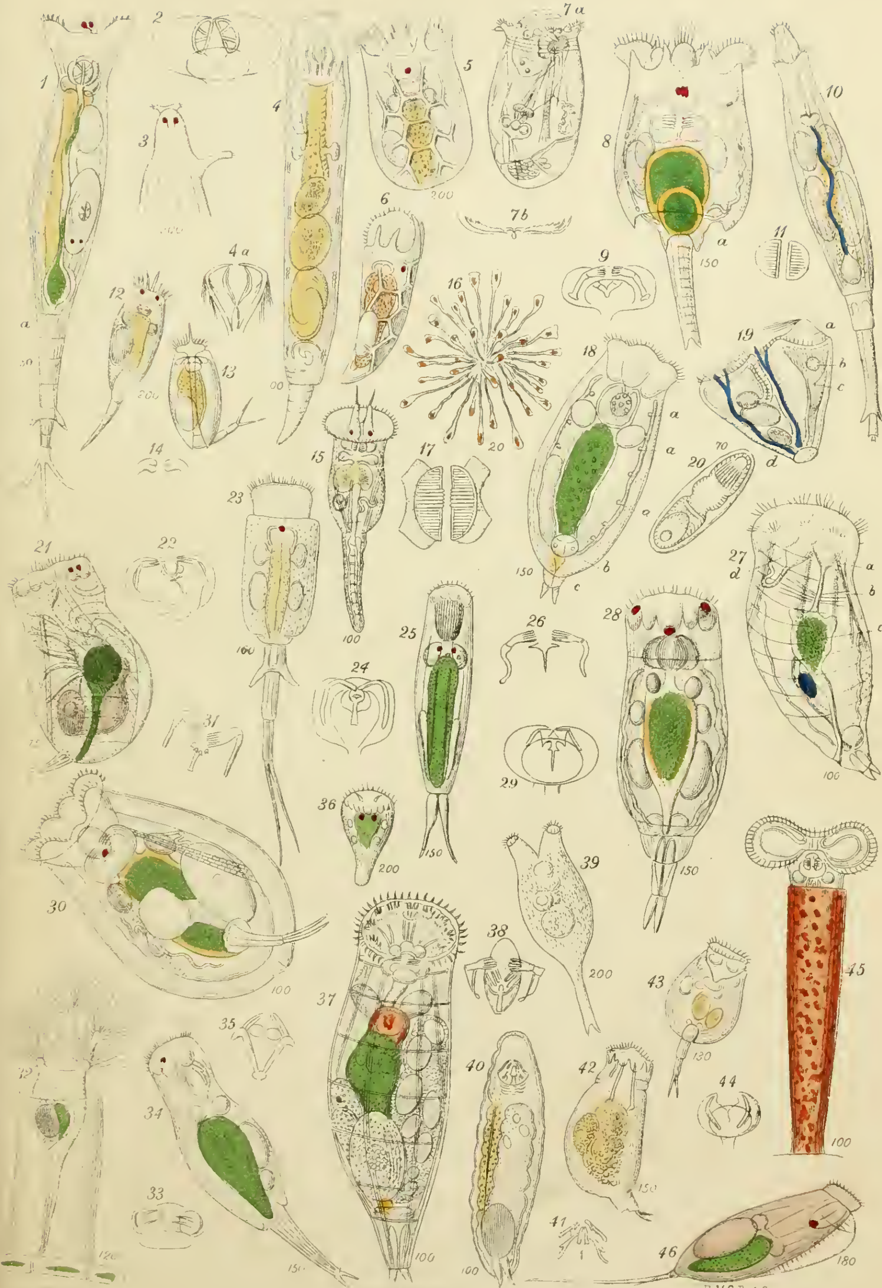
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PLATE 44.—Rotatoria.

Figure
1. *Megalotrocha flavicans.*
2. *Megalotrocha flavicans*, jaws.
3. *Melicerta ringens.*
4. *Melicerta ringens*, removed from its sheath. *a*, rotatory lobes; *b*, lips; *c*, accessory ciliated lobe; *d*, tentacular processes; *e*, pharynx or œsophagus and jaws; *f*, *g*, upper and lower stomach; *h*, anus; *k*, ovary; *l*, oviduct; *m*, spermatic organ? ; *n*, tail; *o*, disk; *p*, sarcodic globules; *q*, ovum.
5. *Melicerta ringens*, tentacular process of. *a*, setæ; *b*, conical body; *c*, muscle.
6. *Melicerta ringens*, jaws of.
7. *Metopidia triptera.* *a*, contractile sac.
8. *Microcodon clavus.*
9. *Monocerca rattus.* *a*, contractile sac; *b*, muscle.
10. *Monolabis gracilis.*
11. *Monostyla quadridentata.*
12. *Monura dulcis.*
13. *Noteus quadricornis.*
14. *Notommata centrura.*
15. *Notommata centrura*, jaws of.
16. *Œcistes crystallinus.*
17. *Philodina erythrophthalma.*
18. *Pleurotrocha gibba.*
19. *Polyarthra platyptera.*
20. *Pterodina patina.*
21. *Ptygura melicerta.*
22. *Rattulus lunaris.*
23. *Rotifer vulgaris.* *a*, contractile sac.
24. *Salpina redunca*, dorsal view.
25. *Stephanoceros Eichhornii.* *a*, tremulous bodies.
26. *Synchæta baltica.*
27. *Scaridium longicaudum.*
28. *Stephanops cirratus.*
29. *Squamella oblonga.*
30. *Triarthra longiseta.*
31. *Triophthalmus dorsalis.*
32. *Theorus vernalis.*
33. *Typhlina viridis.*

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PLATE 45.—Shell, etc.

Figure
1. Calcareous corpuscles of common starfish (*Asterias* (*Uraster*) *rubens*), *a, b, c, d, e*; *f*, the same from an *Ophiura*; *g*, calcareous disk from an *Echinus*; *h, i, k, l, m*, from an *Ophiura* (ECHINODERMATA).
2*. Spine of an *Ophiura*; 2, portion of the same more magnified.
3. A pedicellaria of the common starfish (*Asterias rubens*); on the right hand is a portion of the margin more magnified to show the teeth.
4. Shell of *Pinna*, section parallel to the surface.
5. Shell of *Pinna*, section perpendicular to the surface.
6. Spine of an *Echinus*, transverse section. 6 *a*, segment of the same, more magnified.
7. Section of shell of a *Terebratula*; *a* perpendicular to, *b* parallel with, the surface.
8. Portion of a sponge, with the spicula projecting from its surface.
9. Shell of oyster. *a, b*, sections parallel to surface.
10. Shell of oyster, showing the rhomboidal crystals of carbonate of lime.
11. Shell of oyster, showing the cellular appearance; *a*, parallel with, *b*, perpendicular to, the surface.
12. Shell of hen's egg, from a "soft" egg.
13. Shell of hen's egg, perfectly formed.
14. Shell of egg of ostrich, section parallel to surface.
15. Shell of egg of ostrich, section perpendicular to surface.
16. Shell of lobster, section perpendicular to surface.
19. Anchor-shaped spicular hooks of *Synapta* (ECHINODERMATA).

The remaining figures represent the spicula of sponges.

a. Elongato-fusiform, tubercular.
b. Acicular, acute at both ends.
*b**. Subulato-acicular, base trifid, rays shortly bifid.
c. Subulato-acicular.
d. Subulato-acicular, base swollen.
e. Arcuato-acicular, acute at both ends.
f. Shortly cylindrical, ends doubly trifid.
g. Subulato-acicular, base turbinate.
h. Subulato-acicular, base capitate.
i. Subulato-fusiform.
k. Elongato-subulate, base capitate.
l. Terete, geniculate.
m. Filiform, ends capitate.
n. Acicular, ends bifurcate.
o. Acicular, ends trifurcate.
p. Subulato-acicular, base triradiate.
q. Acicular, base tri-retrocuspid.
r. Uncinato-filiform.
s. Bacilliform, ends tri-retrocuspid.
t. Arcuate, ends uncinate.
u. Stellato-triradiate.
v. Geminate, arms subulato-filiform, geniculate.
w. Stellato-quadriradiate.
x. Stellato-quinqueradiate.
y. Stellato-multiradiate, ends capitate.
α. Subulate tuberculate.
β. Arcuate spinulose, ends clavate.
γ. Stellate inæquiradiate.
δ. Bacilliform spinulose, with dentate, discoid, rotate ends.
ϵ. Globular, with subulate spines.
ζ. Oblong, with irregularly stellate ends, the rays capitate; *, side view.
η. Bacilliform, with stellate rotate ends.

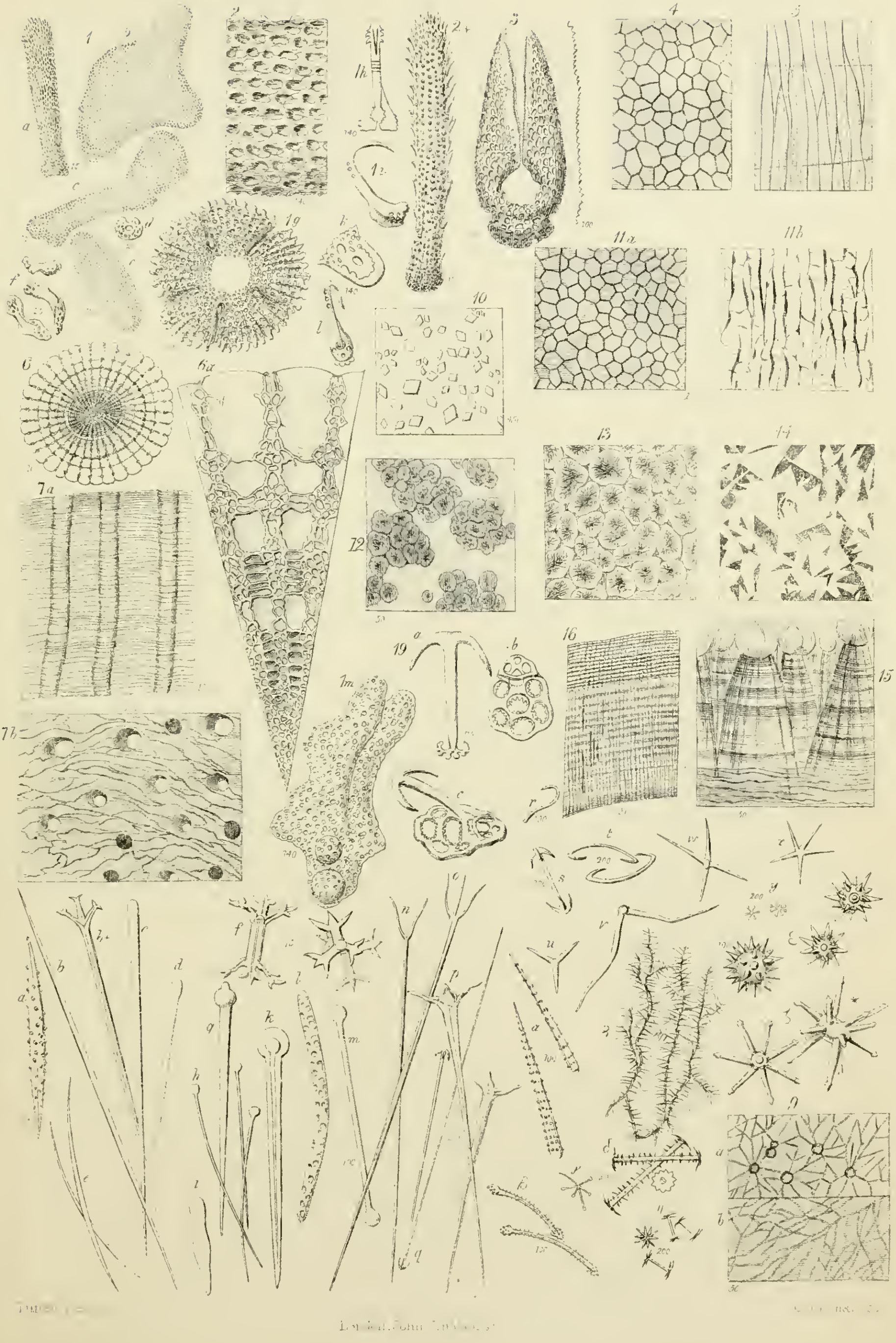


PLATE 46.—Starch.

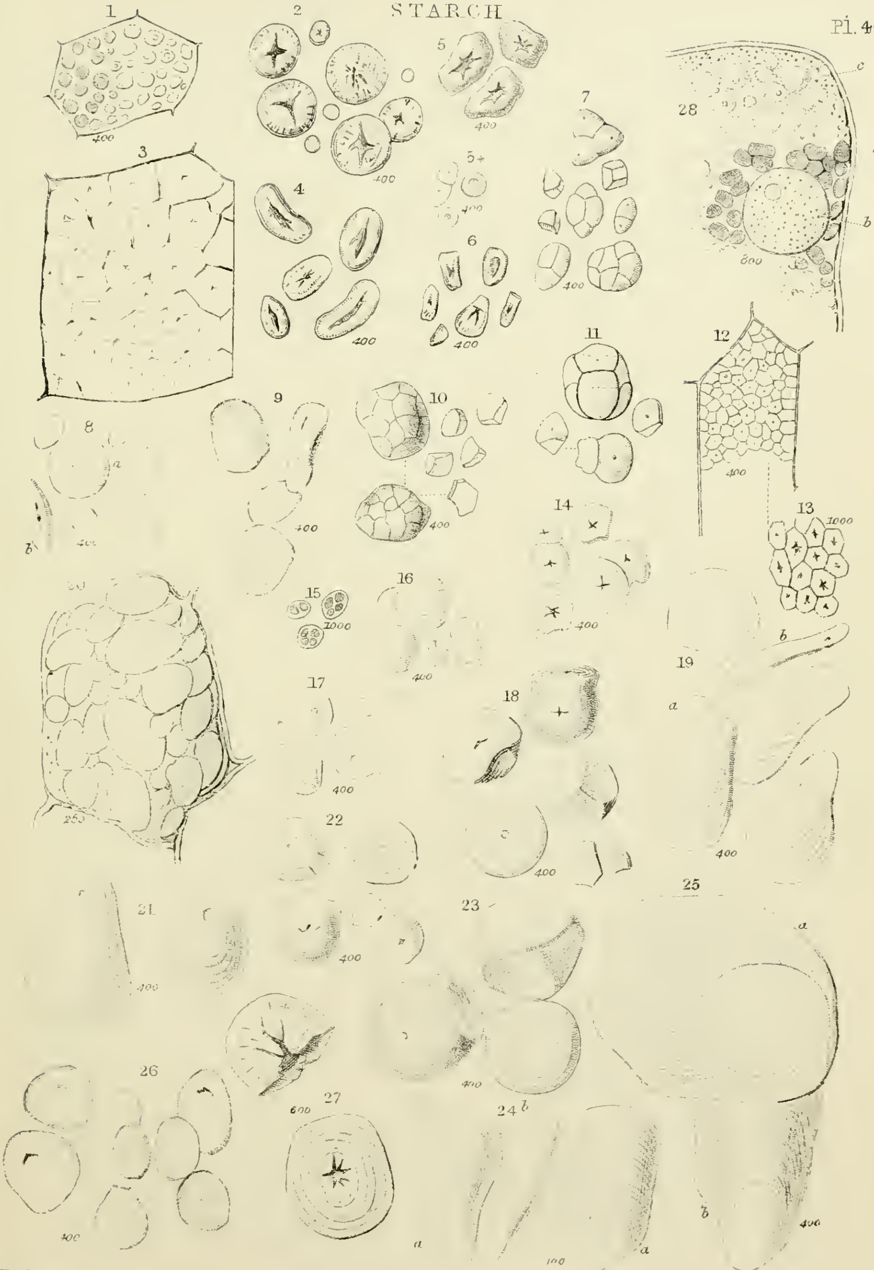
Figure

1. Section of a cell of the albumen of a young maize-seed, showing the nascent starch-grains imbedded in protoplasm.
2. Starch-grains of rye, with a stellate hilum.
3. Section of a cell from the outer horny part of the albumen of maize; the starch-grains completely fill the cell, and by their crowded condition have compressed each other into polygonal forms; the hilum is visible.
4. Starch-grains of bean.
5. Free starch-grains of maize from the cells of the centre of the seed; 5*, young starch-grains of ditto.
6. Starch-grains of orris-root; used to adulterate snuff.
7. Compound starch-grains and separated granules, from the corm of the crocus.
8. Lenticular starch-grains of wheat. *a*, seen in face; *b*, seen edgewise.
9. Discoid starch-grains of barley. *aa*, front view; *b*, edgewise.
10. Compound starch-grains and separated granules of oats.
11. Compound grains and separated granules of Portland arrowroot (*Arum maculatum*).
12. Part of a section of a cell of the grain of rice, exhibiting very minute starch-grains, firmly compacted as in maize.
13. A portion of the same, more magnified.
14. Starch-grains of Cassava (*Jatropha Manihot*)*. Tapioca.
15. Young starch-grains from the cells of the *prothallium* of a fern (*Gymnogramma*).
16. Compound starch-grains and separated granules of the bread-fruit (*Artocarpus incisa*)*.
17. Starch-grains of *Cycas circinalis**.
18. Starch-grains of arrowroot from Singapore*.
19. Starch-grains of an East-Indian arrowroot obtained from a species of *Curcuma**.
20. Cell of a potato, showing the loosely-packed starch-grains.
21. Isolated starch-grains of the potato.
22. Starch-grains of *Tacca pinnatifida*, from Tahiti*.
23. Starch-grains of sago (from a *Sagus*?)*.
24. Starch from plantain-meal (*Musa*). *a*, front view; *b*, edgewise*.
25. Starch of Tous-les-mois (*Canna*). *a*, front view; *b*, edgewise*.
26. Starch-grains of true West-Indian arrowroot (*Maranta arundinacea*).
27. Isolated starch-grains from the cotyledon of a haricot bean.
28. Part of a cell of the stem of the white lily (*Lilium candidum*), showing nascent starch-grains: *a*, forming in cavities of the protoplasm, *c*; *b*, nucleus.

* The figures to which the asterisk is appended were taken from specimens with which we were favoured from the Museum of Economic Botany at Kew.

STARCH

Pl. 46



A. Henfrey ad nat. London. John Van Voorst J. Basire sc.

PLATE 47.—Vegetable Tissues.

Figure
1. Embryo-sac, and supporting cells, of *Orchis morio.*
2. The same, more advanced.
3. The same, with a germinal vesicle at its apex.
4. The same, with three germinal vesicles, just before impregnation.
5. The same, after the pollen-tube (*p t*) has reached it, one of the germinal vesicles (*e*) already being developed to form the embryo.
6. The same, more advanced, showing the first cell of the suspensor (*s*) at the upper end.
7. Embryo-sac of *Lathræa squamaria* before the origin of the germinal vesicles; *p*, amorphous protoplasm; *e*, protoplasm in course of development into endosperm-cells.

8, 9. Apices of very young hairs of the filaments of *Tradescantia virginica*; *n*, *n*, nuclei, containing nucleoli; *p*, protoplasm.

10. Cylindrical cell from which are formed the parent cells of the spores of *Marchantia polymorpha*; *p*, primordial utricles of the parent cells.
11. The same, converted into a string of cells.
12. One of the parent cells isolated, with four primordial utricles of the spores.
13. The four spores free.
14. Transverse section of pith and internal wood of elder; *d*, porous duct.
15. Epidermis of the leaf of the pine-apple, seen from above.
16. Vertical section of cork.
17. Transverse section of ditto.
18. Transverse section of stellate parenchyma of rush-pith.
19. Cellular tissue (parenchymatous) of the leaf of *Orthotrichum pulchellum.*
20. Cellular tissue (prosenchymatous) of the leaf of *Hypnum decipiens.*
21. Section of the albumen of the seed of *Areca Catechu.*
22. The same, after treatment with sulphuric acid and iodine.
23. Section of the bony albumen of vegetable ivory. *a*, cells and pits filled with air; *b*, cells filled with Canada balsam.
24. Cell-membrane of *Hydrodictyon utriculatum.* *l*, the laminæ of the cellulose coat; *p*, protoplasm.
25. Vertical section of the epidermis of a mistletoe-branch several years old.
26. The same, after boiling in solution of potash and treatment with iodine.
27. Transverse section of a liber-cell of the oak, after long boiling in nitric acid and treatment with iodine.
28. Vertical section of the upper face of the leaf of *Cycas revoluta.* *a*, cuticle, extending over the epidermal cells, which, like the deeper-seated cells, have pitted secondary deposits.

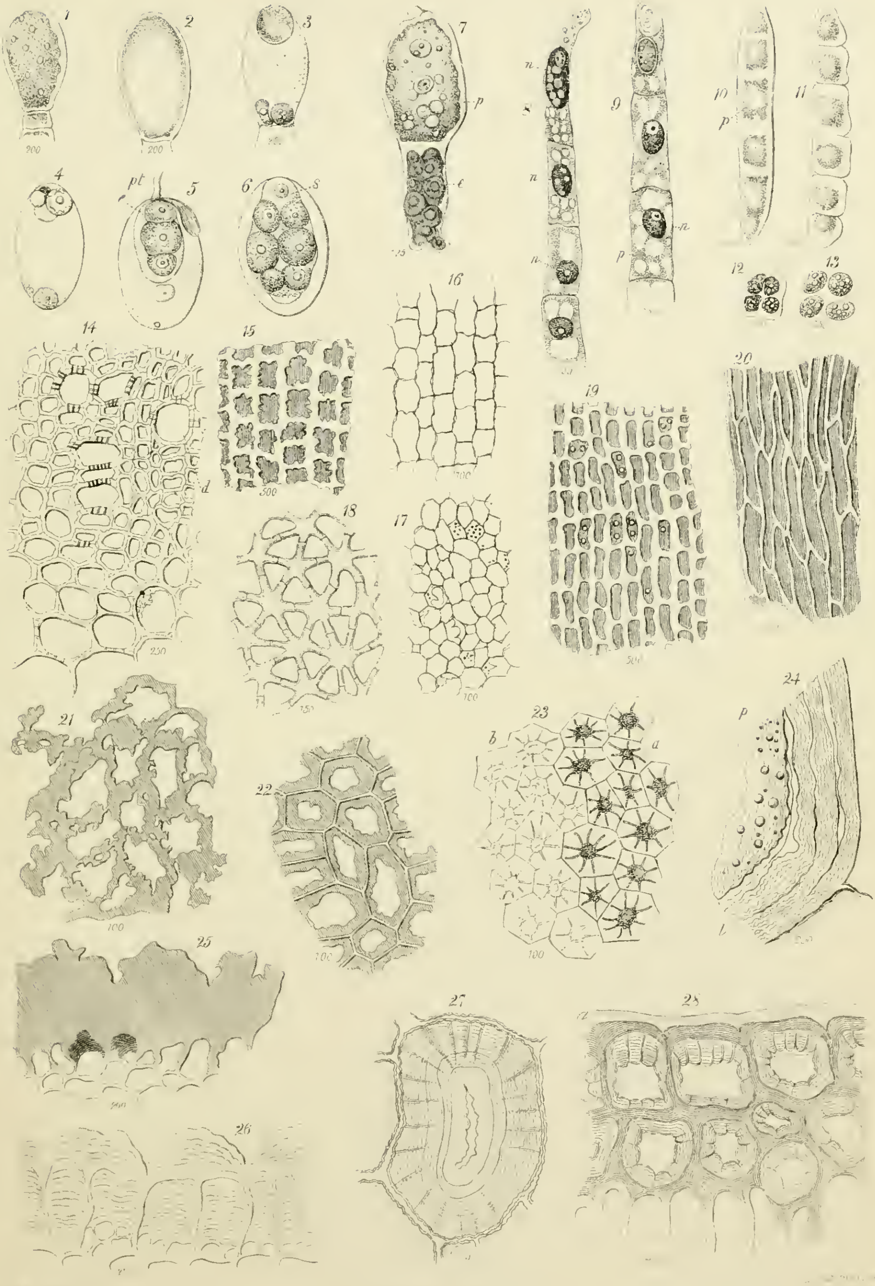
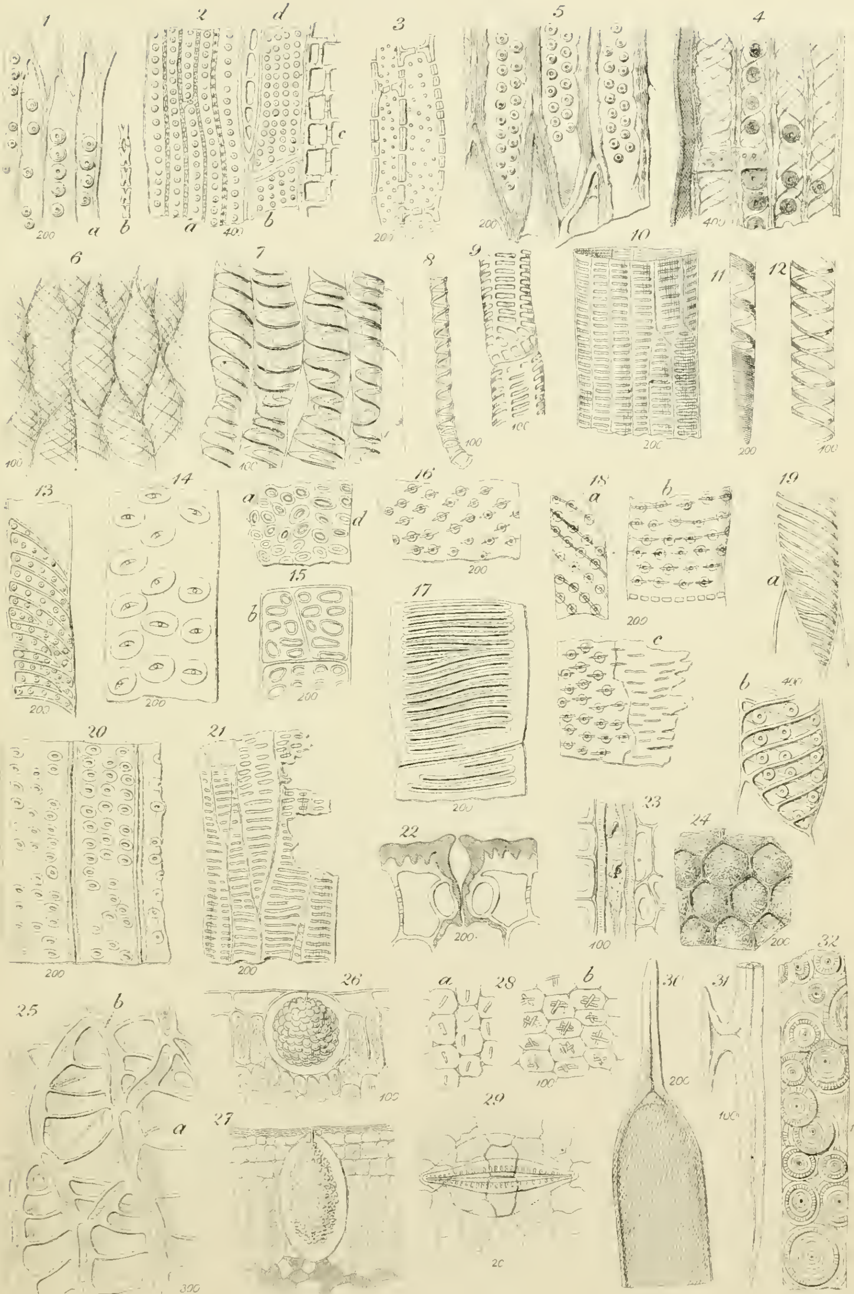


PLATE 48.—Vegetable Tissues.

Figure

1. Wood of *Pinus sylvestris.* *a*, radial vertical section; *b*, tangential section of the walls of two contiguous pitted wood-cells.
2. Tangential section of the wood of *Casuarina equisetifolia.* *a*, pitted wood-cells; *b*, duct; *c*, cells of a true medullary ray; *d*, cells of one of the concentric medullary layers.
3. Vertical section of wood-cells of box.
4. Vertical (radial) section of wood-cells of the yew.
5. Vertical (radial) section of wood-cells of *Araucaria imbricata.*
6. Spiral-fibrous cells from the roots of *Dendrobium alatum.*
7. Wood-cells of *Mammillaria*, with broad spiral bands.
8. Spiral and annular vessels of rhubarb.
9. Reticulated duct from the same.
10. Scalariform duct of a tree fern.
11. End of a spiral vessel of the white lily.
12. Fragment of a larger and looser one.
13. Pitted duct of the lime (*Tilia parvifolia*).
14. Wall of a pitted duct of *Cassyta glabella.*
15. Walls of pitted ducts of *Bombax pentandrum.* *a*, next another duct; *b*, next cells.
16. Wall of a pitted duct of *Laurus Sassafras.*
17. Wall of a pitted duct of *Chilianthus arboreus.*
18. Walls of pitted ducts of clematis (*Clematis Vitalba*).
19. End of a spiral-fibrous duct of *Daphne Mezereon.*
20. Walls of pitted wood-cells of *Cycas.*
21. Fragment of the wall of a large pitted duct of *Eryngium maritimum.*
22. Vertical section through a stoma of *Aloë ferox*; the darkly shaded part represents the cuticular layer.
23. Fragment of a latex-duct of *Euphorbia antiquorum*, the latex containing starch-grains of peculiar shape.
24. Epidermis of the petal of the daffodil, from above.
25. Fragment of the leaf of *Sphagnum cymbiforme.* *a*, empty cells with spiral fibre; *b*, interstitial cells with chlorophyll.
26. Vertical section of the upper face of the leaf of *Parietaria officinalis*, with a cystolith; magnified 100 diameters.
27. A similar section from the leaf of *Ficus elastica*; magnified 100 diameters.
28. *a* and *b*, sections of the cellular tissue of an onion-bulb, containing raphides.
29. Stomata and epidermis of *Equisetum*; the siliceous coat remaining after the destruction of the organic matter.
30. End of a liber-fibre of the periwinkle (*Vinca major*), with fine spiral striæ.
31. Branched liber-cell of the radicle of *Rhizophora Mangle.*
32. Siliceous cast of the inside of a duct of unknown fossil wood; the peculiar concentric concretions of the silica imitate to a certain extent the so-called glandular markings of Coniferæ.

VEGETABLE TISSUES. Pl. 48



A. Henfrey del. R. M. Colling.

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PLATE 49.—Various Objects.

Figure

1. Mixtures of oil and water (Intr. p. xxxvii). *a*, water in oil; *b*, *c*, oil in water.
2. *Oceania cruciata* (Acalephæ), epidermis of.
3. *Oceania cruciata*. *a*, *b*, stinging-capsules with filament included; *c*, with filament expelled.
4. *Diphyes Kochii* (Acalephæ); organs of adhesion upon tentacles.
5. *Oceania cruciata*, portion of margin of disk, slightly magnified. *a*, ovary; *b*, muscular bundles; *c*, transverse vessel coming from the stomach; *d*, marginal vessel; *e*, *f*, tentacular filaments; *g*, auditory organs. 5*, spermatozoa.
6. Infusorial embryos of Acalephæ.

7, 8, 9, 10. The same, further developed.

11. Strobile-segments; *a*, magnified; *b*, natural size.
12. Epidermis of *Triton cristatus* (water-newt).
13. Ciliated epithelium from frog's throat.
14. *Alderia apiculosa*.
15. *Alderia pyriformis*.
16. *Hæmocharis*, epidermis of.
17. *Hæmocharis*, transverse section of muscular fibres.
18. *Hæmocharis*, muscular fibre, showing the sarcolemma.
19. *Hæmocharis*, margin of cephalic disk, with branching muscular fibres *c*; and, *a*, *b*, *d*, glands and ducts. Annulata.
20. *Aphrodita aculeata*, hair of, treated with potash.
21. Blood-corpuscles, human. *a*, *d*, surface view at different foci; *c*, side or edge view; *b*, colourless or lymph-corpuscle; *e*, coloured corpuscles altered, either spontaneously or by mixture with foreign matters, as urine, &c.; *f*, corpuscle changed by tannic acid.
22. Blood-corpuscles of the goat (*Capra hircus*).
23. ,, ,, whale (*Balæna*).
24. ,, ,, ostrich (*Struthio*).
25. ,, ,, pigeon (*Columba*).
26. ,, ,, stickleback (*Gasterosteus aculeatus*).
27. ,, ,, loach (*Cobitis fossilis*); *b*, colourless corpuscle.
28. ,, ,, frog (*Rana temporaria*); *b*, colourless corpuscle; *c*, *d*, the same altered by water.
29. ,, ,, triton (*Triton cristatus*); *b*, colourless corpuscle; *c*, *d*, *e*, *f*, altered coloured corpuscles.
30. ,, ,, *Siren*; *b*, colourless corpuscle.
31. ,, ,, crab (*Carcinus*).
32. ,, ,, spider (*Tegenaria domestica*).
33. ,, ,, cockroach (*Blatta orientalis*).
34. ,, ,, worm (*Lumbricus terrestris*). *a*, corpuscle partly drawn out, as occurs with the bodies of some Infusoria.
35. ,, ,, garden-snail (*Helix aspersa*).
36. ,, ,, human, coloured, undergoing division.
37. Blood, human, in coagulation; *b*, colourless corpuscle.
38. Cartilage of the ear of a mouse; the fat is partly removed from the cells.
39. Cartilage of human rib.
40. Cartilage of human epiglottis.
41. Connective tissue, human, with fat-cells.
42. Formation of connective tissue from cells.

VARIOUS OBJECTS.

Tuffen West del. London John Van Voorst

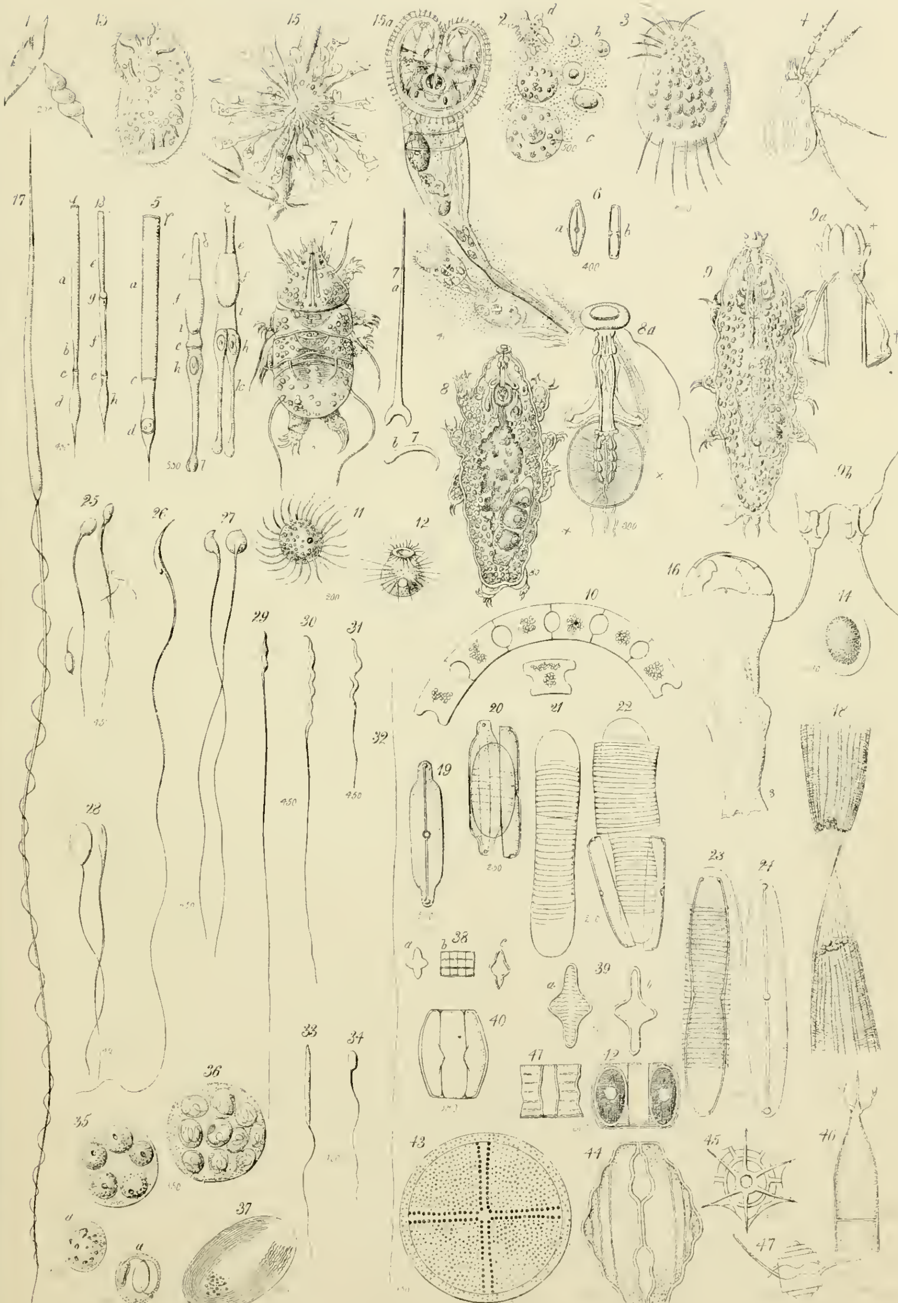
PLATE 50.—Various Objects.

Figure

1. *Chlorogonium euchlorum*, E., undergoing oblique division.
2. Elements of the chyle. *a*, molecules; *b*, free nuclei; *c*, chyle-corpuscles; *d*, one of the same with processes.
3. *Coccudina costata*, D.
4. *Anystis ruricola.*
5. Bacilli and cones of the retina of animals. *a*, *β*, from the pigeon. *a*, bacillus; *a*, proper bacillus; *b*, its pale inner extremity; *c*, line of demarcation at the boundary of the bacillar layer; *d*, corpuscle of the outer granular layer. *β*, cone; *c*, as above; *e*, bacillus of cone; *f*, proper cone; *g*, globule of fat in the same; *h*, expansion of cone. *γ*, from the frog, letters as above. *δ*, from the perch, letters as above; *i*, part at which the cone usually breaks off; *k*, radial fibre; *l*, expansion of inner granular layer. *ϵ*, twin cones.
6. *Frustulia membranacea.* *a*, valve; *b*, front view of frustule.
7. *Emydium testudo.* 7 *a*, isolated style; 7 *b*, claw of leg.
8. *Macrobiotus Hufelandii*; × ovary. 8 *a*. Œsophageal bulb; × its framework.
9. *Milnesium tardigrada.* 9 *a*, pharynx, with + internal buccal lobes, and † styles; 9 *b*, right posterior leg, seen from beneath.
10. *Eucampia zodiaca.*
11. *Halteria grandinella*, D., seen from above.
12. *Halteria grandinella*, D., side view.
13. *Kerona polyporum*, E.
14. *Gyges granulum*, E.
15. *Lacinularia socialis*, E.; 15 *a*, the same, more magnified.
16. Mask (labium) of *Æschna* (Libellulidæ).
17. Spermatozoa of *Triton cristatus.*
18. Sarcolemma of muscle, twisted.

19–24. *Navicula amphirhynchus* in conjugation. Fig. 19, side view of valve of parent frustule; 20, frustules in an early stage of conjugation; 21, sporangial sheath; 22, sporangial sheath with parent frustules attached; 23, sporangial frustule (front view), with sheath and one parent frustule; 24, side view of sporangial sheath.

25. Spermatozoa, human; one exhibiting the so-called spermatozoal membrane.
26. Spermatozoa of rat (*Mus rattus*).
27. Spermatozoa of field-mouse (*Arvicola* (*Hypudæus*) *arvalis*).
28. Spermatozoa of rabbit (*Lepus cuniculus*).
29. Spermatozoa of goldfinch (*Fringilla* (*Carduelis*) *elegans*).
30. Spermatozoa of blackbird (*Turdus merula*).
31. Spermatozoa of wood-shrike (*Lanius rufus*).
32. Spermatozoa of a Coleopterous Insect.
33. Spermatozoa of frog (*Rana temporaria*).
34. Spermatozoa of perch (*Perca fluviatilis*).
35. Spermatic cyst of rabbit, with five globules. *a*, separate globule.
36. Spermatic cyst of rabbit, the cells or globules containing each a spermatozoon. *a*, separate globule.
37. Spermatic cyst of the common creeper (bird, *Certhia familiaris*), containing a bundle of spermatozoa.
38. *a*, *b*, *c*, *Staurosira construens*, E.
39. *Biblarium crux* (*leptostauron*), E.
40. *Goniothecium gastridium*, E.
41. *Periptera chlamidophora*, E.
42. *Periptera chlamidophora*, E.
43. *Aulacodiscus crux*, E.
44. *Goniothecium odontella*, E.
45. *Actiniscus sirius*, E.
46. *Rhizoselenia americana*, E.
47. *Chætoceros didymus*, E.



Tuffen West del.

Edmund Wheeler lith.

Lith. John Van Voorst.

PLATE 51.—Various Objects.

Figure

1. *Coscinodiscus radiatus.*
2. *Cymbella Ehrenbergii.*
3. *Arachnoidiscus indicus.*
4. *Arachnoidiscus nicobaricus.*
5. *Dictyocha fibula.*
6. *Epithemia gibba.*
7. *Podocystis americana.*
8. *Arthrogyra guatemalensis.*
9. *Acanthocystis turfacea.* *c*, forked spicula; *d*, granuliferous tentacles.
10. *Acanthometra bulbosa.*
11. *Acineta mystacina.*
12. *Acineta patula.*
13. *Actinophrys paradoxa*, with capitate (*a*) and actiniform (*b*) tentacles.
14. *Cladogramma californicum.*
15. *Coscinosphæra discoplœa.*
16. *Disiphonia australis.*
17. *Liostephania rotula.*
18. *Goniothecium Anaulus.*
19. *Goniothecium barbatum.*
20. *Goniothecium didymum.*
21. *Goniothecium monodon.*
22. *Goniothecium navicula.*
23. *Goniothecium Rogersii.*
24. *Toxonidea Gregoriana.*
25. *Rhizoselenia alata.*
26. *Mastogloia lanceolata.*
27. *Eunotia tetraodon.* *a*, side view; *b*, front view.
28. *Carpenteria balaniformis.*
29. *Campylopus paradoxus.*
30. *Cadium marinum.*
31. Capillaries: *a*, cells of; *b*, nuclei.
32. *Cercaria furcata.*
33. *Clavularia Barbadensis.*
34. *Cylindrotheca Gerstenbergeri.*
35. *Cymatosira Lorenziana.*
36. *Genicularia spirotænia.*
37. *Gonatozygon Ralfsii.*
38. *Cosmocladium pulchellum.*
39. *Attheya decora.*
40. *Hydrosera triquetra.*
41. *Plagiogramma Wallichianum.*
42. *Perizonium Braunii.*
43. *Dimorphococcus lunatus.*

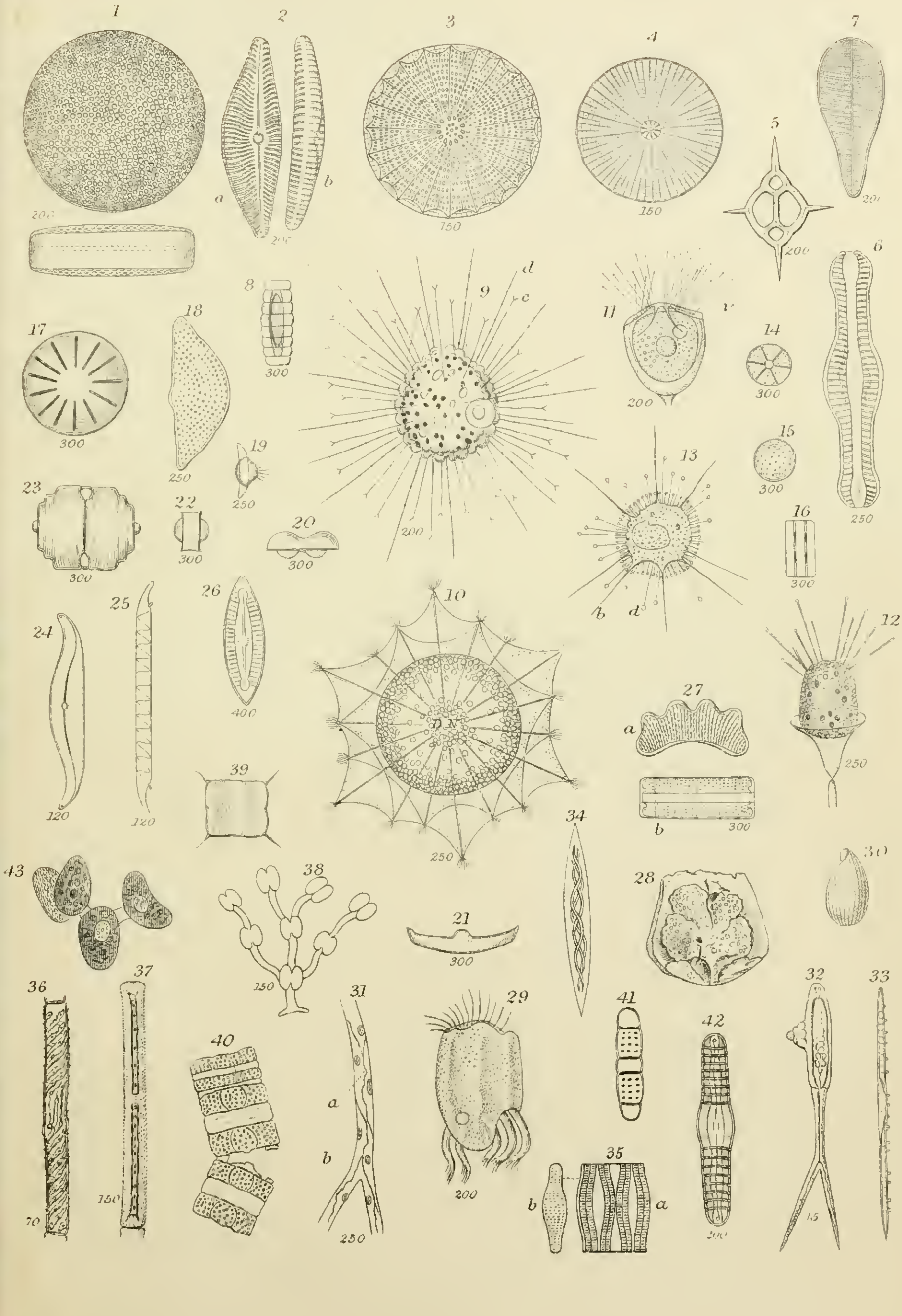

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PLATE 52.—**Various Objects.**

Figure

1. *Freia elegans.*
2. *Gerda glans.*
3. *Gomphogramma rupestre.*
4. *Heibergia Barbadensis.*
5. *Hydrianum ovale.*
6. *Hydrocoleum helveticum.*
7. Transverse section of the SPINAL CORD, after Lockhart Clarke. *a*, antero-lateral columns (white substance); *b*, posterior column; *c*, posterior cornu (grey substance); *d*, anterior cornu; *e*, posterior commissure: in front is the central canal and the anterior commissure; *f*, posterior nerves; *g*, anterior nerves.
8. *Hypheothrix*, species of.

8*. *Anacystis marginata.*

9. *Mastigocladus laminosus.*
10. *Mastigothrix æruginosa.*
11. *Metopus sigmoides.*
12. *Mischococcus confervicola.*
13. *Liradiscus Barbadensis.*
14. *Limnodictyon Rœmerianum.*
15. *Urnula epistylidis.*
16. *Petalopus diffluens.*
17. *Plagiophrys cylindrica.*
18. *Pleurococcus vulgaris.*
19. *Rhoicosphenia*: *a*, *curvata* *b*, *marina.*
20. *Schizopus norvegicus.*
21. *Staurogenia quadrata.*
22. *Stephanosphæra pluvialis.*


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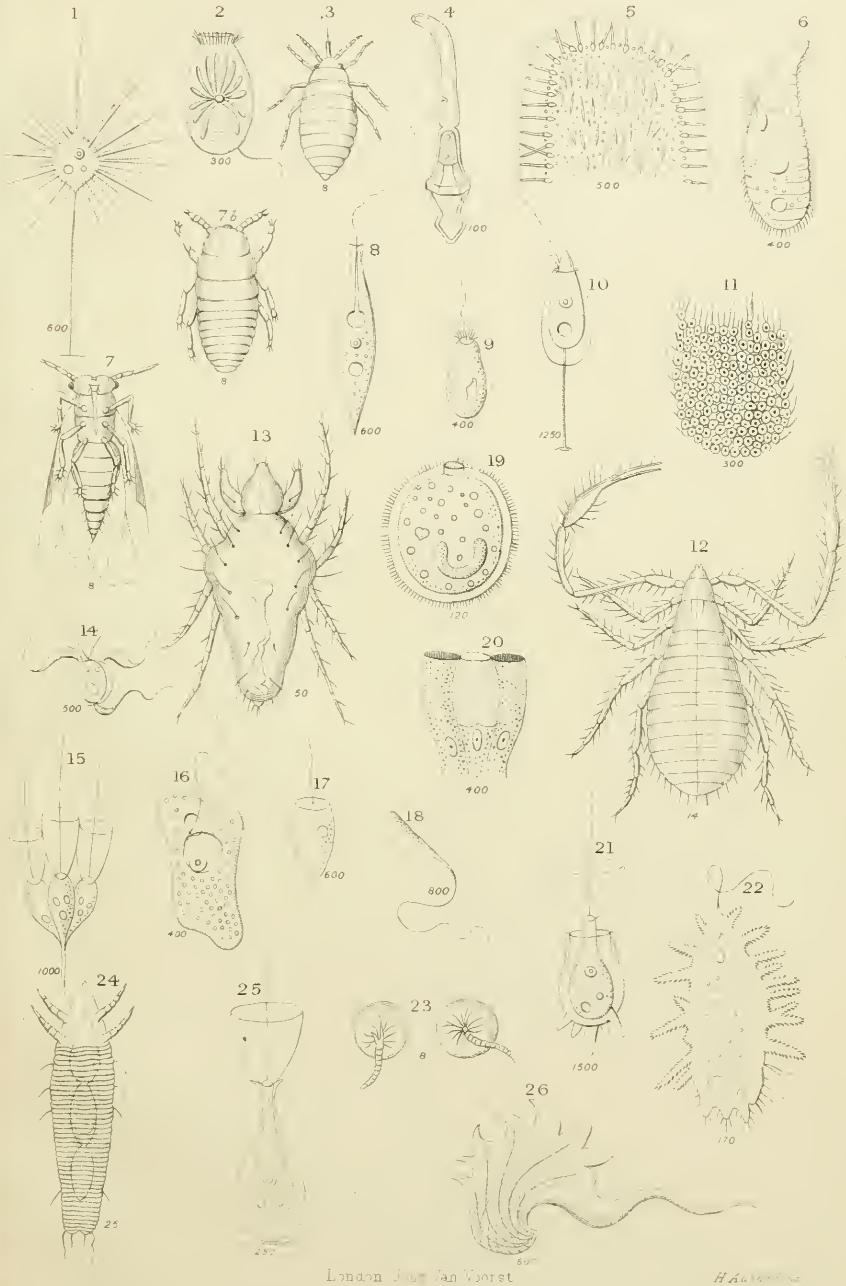
PLATE 53.—Various Objects.

Figure

1. *Actinomonas mirabilis.*
2. *Amphidinium operculatum*, with nuclear prolongations.
3. *Eriosoma lanigerum.*
4. *Anchylostoma dysenterica*, fem.
5. *Amylobacter*; portion of cell of the pith of the fig-tree, lined with *Amylobacter.*
6. *Anophrys sarcophaga.*
7. *Phylloxera vastatrix.*
8. *Atractonema teres.*
9. *Asthmatos ciliaris.*
10. *Bicosœca lacustris.*
11. *Capsosira Brebissonii.*
12. *Chelifer cancroides.*
13. *Cheyletus eruditus.*
14. *Colpodella pugnax*, attached to a cell of *Protococcus.*
15. *Codosiga botrytis.*
16. *Cœlomonas grandis.*
17. *Cyathomonas spissa.*
18. *Herpetomonas Lewisi.*
19. *Ichthyophthirius multifiliis.*
20. Goblet cells (p. 439).
21. *Lagenœca cuspidata.*
22. *Mastigamœba aspera.*
23. *Noctiluca miliaris.*
24. *Phytoptus tiliæ.*
25. *Salpingœca amphoridium.*
26. *Trypanosoma sanguinis.*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